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USE AND MANAGEMENT OF IRRIGATION WATER FOR RICE PRODUCTION IN FOREIGN COUNTRIES [1]

ANDRES P. AGLIBUT [2]

I would like to think of irrigation as an endless chain of activities that is composed of seven links, each representing some set of specific functions of men either in a government or in a private irrigation enterprise. The following are the functions and activities, and each of these, in turn, may embrace some integrated activities: (1) investigation and survey, (2) planning and design, (3) financing and construction, (4) operation and maintenance, (5) use and management of water, (5) organization and management of irrigated crop enterprises, and (7) research. Because the strength of a chain is dependent upon its weakest link, it can be said that the effectiveness of an irrigation program of a country depends on the performance of the different offices represented by the links in the chain.

The first four groups of activities are concerned with engineering, the next two, strongly with agriculture and economics, and the last, a combination of the two. Undoubtedly, the Irrigation Division of the Bureau of Public Works has done a good job of welding strongly the engineering links. The accomplishment of that office speaks highly of the ability of the men running its affairs. The same can be said, with the same force and essence, of the Irrigation Service Unit, which owes part of its strength to the United States government through the ICA, Manila with regard to the speedy implementation of the pumping irrigation program of the government. But even with our serious and sustained effort of using more water for the production of lowland rice, in the best way we know how, I venture to say that the agricultural, economic, and research links are relatively the weakest in the irrigation chain. This is due to the lack of basic local information on more effective use and management of irrigation for the production of lowland and upland crops,

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[1] General Contribution No. 879. Paper read at the Seminar of the Soil Science Society of the Philippines held in Manila on April 15, 1957. Data presented in this paper were gathered partly through conferences and interviews with experiment station officials and farmers in countries visited by the author in the course of his recent travel sponsored by the Rockefeller Foundation, and partly from references cited in the paper.

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and the limited employment of men trained in agriculture and farm management in irrigation entities.

In our desire to strengthen the links of research and the use and management of water for the production of lowland rice, we busily engage ourselves in intensive research on rice irrigation. We hold regular field days during which the results of such research are demonstrated to our farmers. We even send experts abroad to observe the latest and most progressive irrigation practices of other countries. And because we can profit from the good practices of these countries I decided to speak on this subject when Mr. Romero, the Secretary of the Soil Science Society of the Philippines extended to me the invitation. I hope that this opportunity of speaking on what I know and observed, on the use and management of irrigation water during my recent travel through some rice producing countries abroad would be of some use and help to us.

USE AND MANAGEMENT OF IRRIGATION WATER

West Java, Indonesia

West Java is one of the countries where the production of lowland rice with controlled irrigation is a general practice. Van der Giessen (1946) classifies rice areas in the country into (a) those areas dependent entirely upon rain, hence, cropped with upland varieties, (b) those that are dependent partly upon rain and partly upon irrigation where lowland rice varieties are planted, and (c) marshy areas which could be cropped with the aid of drainage, especially during the rainy season.

In the utilization and conservation of its water resources, the provision of funds for sustained construction, operation and maintenance of irrigation systems, the effectively increasing use and management of water by the farmers, and research directed toward increasing production through proper use of water in consonance with other production factors and cultural practices, I can say that Indonesia has made worthwhile progress. Van der Giessen showed the progressive increase of lowland rice area irrigated by government systems: 210,000 hectares irrigated by systems constructed before 1885; 255,000 hectares between 1855 and 1910; 470,000 hectares between 1910 and 1930, and 1,310,600 hectares up to 1940. The Irrigation Office, Department of Public Works of Indonesia informed me that World War II and the Civil War that followed temporarily stopped construction of new projects from 1941 to 1948. Mr. H.

Siregar, Chief of the Rice Research Institute in Bogor, informed me also that in Java the total area irrigated by native and government systems was about 2,925,000 hectares out of approximately 3,441, 300 hectares under rice production in 1956.

A very interesting aspect of irrigation activities in Java is the active participation of experts in surveying the agricultural and economic phases of a project to determine its feasibility prior to approval and construction. And in the operation of a system, Van der Giessen (1946) explained the cooperation between three agencies—the government administration, the irrigation service and the agricultural service—that compose the local irrigation committee. This committee issues, among others, regulations covering such matters as time of sowing, area to be planted and irrigated, schedule of delivery of water, and manner of application of water. Because delivery of water to the farmers is supervised by the irrigation service of the local committee, and the farmers take charge of using the water in their fields, harmonious relations between these two parties are essential for a strong and successful operation of an irrigation program.

Consumptive use of water by rice. Irrigation research undertaken in Java covered varied problems such as quality of irrigation water from different sources, duty of water, weed control, use and management of irrigation water in rice production, and others. Because of the importance of studies on consumptive use of water by rice, and their bearing on the subject discussed in this paper, I would like to present some of the results of a study conducted by Van de Goor (1950) during the 1948-49 season in the experiment station at Muara, Bogor, Java, using the rice variety Mas, in clay loam soil.

The results of the study show that from land preparation to maturity, a period of 142 days, the average rate of flow of irrigation water used was 2.63 liters per hectare per second, and a total depth of 3.32 meters of water per hectare. The evapo-transpiration varied from 0.25 to 0.5 liter per hectare per second, which was but a small part of the loss due to seepage. As cited by Van de Goor, earlier experiments of Den Berger (1910) gave average values of 3.2 and 2.1 liters per hectare per second. Much water was used during land preparation, 4.67 liters per hectare per second; during pretillering period (13 days beginning from 40 days after transplanting), 4.88 liters per hectare per second; and during the flowering or heading stage (21 days), 3.37 liters per hectare per second.

By comparing the required water supply at different stages of growth with the average flow of supply during the whole period, Van de Goor found the following ratios: for seedbeds and preparing the land, 1.50; during the first two weeks after transplanting, 0.75; during tillering phase, five to seven weeks, 1.0; during flowering or heading, three weeks, 1.25; and two to four weeks after flowering, 0.625.

Common irrigation practice. Mr. Siregar described to me the irrigation practice of farmers in West Java. Seedlings may be transplanted with or without water in the puddled paddy. If the paddies are drained at transplanting, the water is admitted soon after, if not two or three days later, and kept to a depth of about 10 centimeters. First drainage of the field lasting three to five days takes place at about 30 days after transplanting, corresponding to weeding time. The paddies are again submerged to a depth of about 10 centimeters until flowering. Second drainage lasting three to four days for the purpose of securing more uniform flowering then takes place. Following the second drainage the paddies are again submerged to the same depth, and remain submerged until three to four weeks before harvest. While some farmers transplant their seedlings in puddled, drained paddies, others do so with their paddies submerged in water with depths varying from seven to ten centimeters. The advantages of transplanting in water include faster recovery of the transplants, prevention from breaking of seedlings especially during windy days following transplanting, and better control of weeds. The main disadvantage however, is the possible floating of some new transplants which are not planted properly.

Thailand

Rice is the principal crop for food and export. There are two important problems related to irrigation of this crop, namely: constant occurrences of either early or late drought and too much water when the rains fall with a prolonged duration during the growing season. Because of the importance of the crop and its basic relation with the nation's economy, the government launched elaborate five-year programs of constructing irrigation and drainage works for the proper conservation and regulation of irrigation water especially in the big Central Plain of the country, commonly known as the "rice bowl" of Thailand. The plain is a broad, nearly equilateral triangle having a side of roughly 150 kilometers with an area of

about 273,000 hectares, according to the 1950 reports of the Thailand Ministry of Agriculture.

Grist (1955) reported that rice grown in Thailand requires about six feet of water. But in the Central Plain the total annual rainfall is less than the total requirement by about 2.5 feet. To augment this deficit, the Department of Irrigation, Ministry of Agriculture of Thailand, utilized the excess natural waters in streams flowing through the plain, of which the Chao Phya River is the biggest. Hence, the construction of irrigation works, which, according to Grist, are mainly canals connected to rivers by means of sluice gates. Because these canals are broad and of sufficient depth, they also serve as waterways for transportation, which are much in use in the country. The gates can be opened to admit irrigation water into the canals for the rice fields, and can be closed to maintain lower levels of water in the canals to permit drainage of the fields.

At present, the existing irrigation systems are still inadequate to supply controlled water for the culture of rice. Hence, there is still much dependence upon the uncertainties of rainfall. And since the Central Plain is often flooded following heavy rains, deep-water rice, commonly known as "floating rice" is planted by broadcasting in the lower parts of the Plain. The ordinary lowland rice is usually transplanted in the higher levels which do not easily get flooded during prolonged rains. Driving northward along the highway from Bangkok to Lopburi last June, we observed some floating rice almost under water in the low fields and the ordinary transplanted rice on the higher levels.

In Thailand many observations and calculations of duty of water have been made. The report of the Ministry of Agriculture (1950) gives water requirement of ordinary lowland rice with a growing period of 120 days, itemized as follows:

Total water requirement	120.0 cm.
Average rainfall	52.8 cm.
Irrigation water required	67.2 cm.
Allowance for losses in the system	48.0 cm.
Water to be drawn at headgates	115.2 cm.
Expressed in liter per hectare per second	1.11

The water requirement that must be provided by irrigation is 1.11 liters per hectare per second, applied continuously for a period of 120 days. The value is low compared to that of Indonesia, perhaps

because the lowland soil in the Central Plain of Thailand is generally clayey and holds water very well.

Japan

Rice which is the staple crop is produced with the most intensive cultural methods, attention and care. Amatatsu (1956) who cited statistical figures of the rice hectarage in 1954 reported that of the 3,045,823 hectares planted to rice, 95.5 per cent was in lowlands and 4.5 per cent in uplands. The rice area was 38.7 per cent of the total area planted to all major crops. Japan is internationally known for its highly developed and intensive methods of rice culture. And in rice research the country is considered foremost in breeding and improvement, cultural practices and methods, processing and utilization, control of pests and diseases, development of equipment and many other aspects.

Rice research pays dividends. The use and management of water by the Japanese farmer in his lowland rice production has reached a high level of perfection in all the rice producing areas of the country. The proper depth of water to use at the different stages of growth and development of the plant, how to use it, and the best temperature range of the water have been determined with success. At present the Japanese irrigation scientists are busy conducting studies on upland rice irrigation. With the pursuance of a vigorous government program of training scientists and technicians and proper recognition of scientific achievements, scientific research in Japan will continue to pay dividends.

Use of irrigation water. Irrigation water for rice growing is used in land preparation, growing seedlings, and during developmental stages of the crop. When the fields for the crop are plowed dry clods are formed, which are crushed with an animal-drawn plow after being saturated and softened with irrigation. Puddling two or three times with a rotary plow follows, after which the field is submerged to keep it soft for transplanting. If the field is drained at transplanting, it should be irrigated to a depth of about 10 centimeters for four to seven days after transplanting to maintain an even temperature at night, control weeds and stabilize seedlings during the early stage, and facilitate rooting (Matsuo, 1955).

One week after transplanting, the water depth in the field is reduced gradually to about five to three centimeters to raise the temperature in the root zone of the transplants. This promotes

growth and tillering of the plants. Constant morning refill of the field to five or three centimeters is necessary to keep a fairly uniform soil temperature.

Drainage. The field is drained for 7-14 days to dry the soil surface near the end of the tillering stage, about 40 days before flowering. Matsuo reported good results of this drainage. In temperate countries like Japan, the depth of submergence is increased to about 15 centimeters at this stage of the plants to protect the young flowers and heads from the adverse effects of low temperatures. Gradual drainage takes place from the dough stage and is completed in about 20 days after heading. This schedule of drainage may be modified depending upon the water supply and drainage condition of the area.

Warming irrigation water. In temperate countries where rice is produced with irrigation from cold waters, it is necessary that the temperature of the water be raised by allowing it to stand for sometime in shallow broad concrete or earthen tanks, then conveyed in shallow streams to the field. This concrete-tank method was used in Aritsuka Experiment Station, and the temperature of the water pumped from an irrigation well could be raised from 18°C to 26°C or more depending upon air temperature.

Irrigation of upland rice. Studies on the irrigation of upland rice were initiated during the last rice season (1956) at the above station. The studies were intended to determine water requirement of upland rice, infiltration rate in the soil and proper irrigation shedule to be followed for upland rice. With the present pace that the Japanese irrigation scientists are working on this problem, it can be safely said that irrigation of upland rice will soon be a common practice in Japan.

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MINERAL CONTENT OF FOUR SOILS REPRESENTING MAJOR SOIL TYPES OF THE PHILIPPINES [1]

N. L. GALVEZ [2]

WITH EIGHT TEXT FIGURES

The surface soils of Lipa clay loam, Guadalupe clay, and Baao clay in southern Luzon had at moisture saturation pH values ranging from 5.55 to 5.82. The lower horizons showed reactions from pH 4.55 to 7.20 depending on the materials mixed with the soil particles.

Guimbalaon soils in Negros showed higher acidity than the southern Luzon soils, the pH value of the former being 4.35 whereas the latter, 5.5. The lower horizons of Guimbalaon were more acidic than the surface and its acidity increased with depth.

Extractable iron of the southern Luzon soils decreased with depth while Negros soil did not show a definite trend of result.

The distribution of sand, silt and clay fractions varied with soils and depth. Lipa clay loam decreased with depth, its total silt and clay fractions decreasing from 38 to 32 per cent and 45 to 13 per cent, respectively. Guadalupe clay showed similar trend of results. Baao decreased its silt fractions from 14 to 2 per cent while its clay fraction increased from 68 to 94 per cent with depth. Guimbalaon showed 62 to 71 per cent in the volume decreasing to 35 per cent below 50 inches.

The x-ray diffraction patterns indicated that Lipa clay loam, Guadalupe clay and Baao clay showed all broad basal spacing in the region of 18A strongly indicating the presence of minerals dominantly montmorillonite interstratified with illite-vermiculite and intergradational vermiculite-chlorite phosphorus ferro-allophane-like minerals. Feldspar and cristobalite were also present.

Guimbalaon clay is dominantly halloysite mixed with some amounts of montmorillonite vermiculite-chlorite-illite.

The existence of layer silicates was strongly supplemented by the results obtained from the dehydration loss, DTA, elemental chemical analysis and x-ray of random powder specimen.

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[1] Miscellaneous Contribution No. 34.

[2] The author is grateful to (a) the John Simon Guggenheim Memorial Foundation for the fellowship grant and to Professor M. L. Jackson for his suggestions during the progress of the study; (b) the members of the faculty and research staff of the Department of Soils, University of Wisconsin, for their cooperation; (c) the Graduate School for an appointment as honorary fellow at the University of Wisconsin; (d) Wisconsin Alumni Research Foundation for gift funds used in the procurement of chemical reagents, and (e) Messrs. M. Raymundo and M. C. Lopez of the Department of Soils, College of Agriculture, U.P., for help in collecting the samples.

The mineral content of soils, which is the result of a long period of soil formation and which consists of more than one type constitutes an active portion of soils. It is particularly active in the chemical, physical and microbiological phenomena concerned with the maintenance of the optimum soil-plant relationships. Soil reaction and its ability to fix phosphate, exchange ions and conserve plant nutrients are associated with the dominant type of clay minerals. The tendency of soil to flocculate and disperse, to aggregate and swell, to form a definite structure and its permeability to air and moisture are resultant activities of the clay minerals. The 2:1 type clay minerals are highly hydrated whereas the 1:1 type, only slightly hydrated. These properties affect drainage and stickiness. Soil material derived from crop residues, appear to vary in level depending on the type of clay minerals.

The efficiency of organic compounds, consisting of very large ionic organic molecule like krilium to hold the solid soil particles in a loose net and at the same time reduce the water-holding capacity by coating some of the clay mineral surfaces, varies with the clay mineral content of soils.

There is voluminous data on the chemical, physical and microbiological properties of Philippine soils but none on the mineral content. It is believed that this additional information will be of value in the interpretation of differences in the response to management practice of some Philippine soils.

For this reason, a study of the dominant minerals in the clay fraction of four major Philippine soil types was undertaken in the Department of Soils laboratory at the University of Wisconsin from January, 1956 to July, 1956.

REVIEW OF LITERATURE

Peterson (1946) reported that kaolinite is inert as a binding material and has no influence on soil aggregation; on the other hand montmorillonite, because of its greater surface, charge and hydration, is an effective cementing agent and induces aggregation. He also finds that kaolinite is associated with the formation of platy structure whereas montmorillonite, of blocky structure.

Ensminger (1942) found that montmorillonite sorbed portions of lignin and proteins resulting in the decrease of base exchange capacity.

Ensminger and Gieseking (1941) reported that gelatine and albumin not only are sorbed by montmorillonite but also enter the variable space between the layer packages thus reducing the swelling which normally results from the absorption of water.

Buehrer and Rose (1943) and Buehrer and Aldrich (1946) have demonstrated that the constituent minerals of the colloidal fraction were associated with the phenomenon of water sorption. In kaolinite and silien, it was a purely surface phenomenon while in montmorillonite it was a function of the expanding lattice.

Buehrer, Robinson and Deming (1949) stated that the formation of claypans and the ease with which desert soils of low organic matter content pass into puddled condition show relations with the colloidal minerals.

Jones and Hoover (1949) found that very acid soils containing 2:1 clay minerals require more lime and have higher base exchange capacities than very acid soils containing kaolinite (1:1) having organic matter content and pH values equal to the 2:1 type.

Stout (1939) reported that phosphate fixation by simple ionic exchange in which the hydroxyl groups of the clay interface exchange with the phosphate ions in solution is most likely to occur in kaolinite clays rather than in a montmorillonite type of clay because of the characteristic of the crystal structure. Kaolinite and halloysite adsorb much more phosphate than bentonite.

Chu and Sherman (1952) found that plants grown on montmorillonitic soils produce a greater plant growth than those grown in kaolinitic soils.

Truog (1938) reported that reaction of soil minerals with phosphate is the main cause of fixation.

Scarseth (1935) advanced the hypothesis that the soil colloids consisting of alumino-silicate minerals can fix phosphate by adsorption.

Mattson (1932) and Waksman (1936) suggested that the resistance of some organic materials to biological decomposition are increased when they are adsorbed by the clay minerals.

Ensminger and Gieseking (1942) showed that the decay characteristics are often quite different in free as compared to clay-mineral-adsorbed organic material. In some cases the reaction seems to be catalyzed by the clay minerals. It has been known for many

years that certain clay materials, notably some montmorillonite and attapulgite have the power to decolorize oils and at the same time may cause changes in the oil by catalysis.

MATERIALS AND METHODS

Lipa clay loam is the dominant soil type in the upland fields of the provinces of Batangas and Laguna. It is derived from the weathering of volcanic tuff under a rainfall of 2,233 mm. during the wet season and 244 mm. during the dry season. With favorable climatic conditions, this soil type has been giving good response to the application of nitrogen. At moisture saturation its pH value in the 0-6" horizon is higher than in the lower horizon (table 1).

Guadalupe clay, although also formed from the weathering of volcanic tuff under condition similar to that which prevail in the Lipa clay loam region, is highly responsive to the use of both nitrogen and phosphorus. Its pH value increased with depth.

Baao clay has been developed on a recent siliceous ash on top of limestone deposit under condition without distinct wet and dry seasons. The total rainfall during the year was 3,336 mm. Its pH value showed alkaline reaction with depth.

Guimbalaon clay [3] was formed from old acidic volcanic materials under condition similar to that of Baao clay. However, its total rainfall was only 1,564 mm. during the year. Its pH value is much lower than the other three types with a strong tendency to become more acidic in the lower horizons.

Since no single method has been found satisfactory for accurate identification of the mineral contents of soils, various techniques giving results that complement one another have been employed in the present study.

The soil being a complex multi-component system, it may be expected to have large-particle components with characteristics that overshadow those of smaller ones. For this reason, the samples were first fractionated in accordance with the details of the methods of Jackson *et al.* (1950). Since the presence of extractable iron oxides influences the effectiveness of the segregation procedure, free Fe_2O_3 was removed before the dispersion treatment with 2% Na_2CO_3 solution (Aguilera and Jackson, 1953).

[3] Furnished by the Research Department of the Victorias Milling Company.

TABLE 1.—*Description of the soil types and their use*

SOIL TYPE AND LOCATION	PARENT MATERIALS AND RAINFALL DISTRIBUTION	FERTILITY AND PRESENT USAGE	PROFILE DESCRIPTION	SOIL pH (MOIST SAT. %)
1. Lipa clay loam Batangas and Laguna, Southern Luzon	Acidic (57% SiO_2) volcanic tuff Distinct wet and dry seasons Wet season—6 mos. 2,233 mm rainfall Dry season—6 mos. 244 mm rainfall	High fertility Planted to corn, sugar cane, rice, oranges, coffee, cacao; pasture	0-6″ dark brown friable and mellow 6-12″ slightly finer textured than the upper layer 12-18″ highly weathered 18-36″ similar to upper horizon Below 36″ fragile gravelly volcanic tuffs	5.70 4.55 4.70 5.00 5.45
2. Guadalupe clay Rizal, Cavite and Batangas Southern Luzon	Acidic volcanic tuff Distinct wet and dry seasons Wet season—6 mos. 2,233 mm rainfall Dry season—6 mos. 244 mm rainfall	Responsive to N and P. Mangoes, rice, corn; pasture	0-6″ dark brown, very plastic when wet; hard when dry 6-12″ lighter color, otherwise similar to above 12-18″ grayish brown highly weathered silty tuffs Below 18″ tuffaceous materials harder than that of Lipa	5.55 5.70 5.85 5.82
3. Baao clay Albay Southern Luzon	Recent (1938) siliceous volcanic ash on top of limestone deposits No distinct wet and dry seasons Total rainfall, 3,386 mm.	Average fertility Rice, corn; pasture	0-6″ black with clayey consistency 6-12″ same as upper layer but lighter in color. Presence of limestone. 12-18″ grayish brown Below 18″ limestone mixed	5.82 7.00 7.20
4. Guimbalaon clay A Latosol (Cline) Occidental Negros, Visayan Islands	Old acidic volcanic materials No pronounced wet and dry seasons Total rainfall, 1564 mm.	Problem soil for sugar cane production. Slow growth. High amounts of K seem to help.	0-15″ friable reddish clay 15-40″ sticky, concretion; effervesces with H_2O_2 40-50″ brownish red. Soft and brittle rocks present Below 50″ reddish rocks and boulders	4.35 4.10 3.95

In the exploratory study of the samples, the X-ray diffraction method was employed using G. E. XRD-3 diffraction unit equipped with Geiger counter recorder. This is based on the fact that the layer silicate minerals settle from suspension and align themselves parallel with the Z axis perpendicular to the surface. The sample was first boiled with N NaOAc solution before it was subjected to Mg-saturation and glycerol solvation. This method was used to differentiate the montmorillonite and the vermiculite series from illite. Potassium-saturated specimens heated at 400°C and 500°C, were employed in the differentiation of vermiculite from chlorite and in establishing the presence of x-amorphous interstratified 2:1 layer silicates and kaolinite and halloysite (Jackson, 1949).

Differential thermal analysis (DTA), which is based on the endothermic reaction of minerals due to the removal of water or hydroxyl ions from the mineral structure, was carried out in a furnace heated uniformly at the rate of 10 centigrade degrees per minute. The Ca clay sample is packed lightly with a nickel spatula into the sample block cavity which is connected to a reference cavity, similarly filled with ignited Al_2O_3 powder. The system is connected to the DTA X-versus-Y recorder.

The integral thermal analysis, which is based on the volatilization of structural water and hydroxyl ions, was applied on hydrogen-saturated clay by heating the sample for six hours at different temperatures in a well-controlled furnace and then taking the weight at each succeeding temperature.

The powder-wedge method of analysis was carried out on Ca-clay sample (Jackson, 1949). This method is recognized to be efficient in identifying small amounts of minerals and their *hko* spacings even when the basal material was dissolved.

Electron micrography, well recognized as a good coordinator of other methods in mineralogical identification in soils, was used in determining the crystal form and size of minerals. The specimen was first dialyzed before bringing into suspension (approximately 0.001 per cent) and dropping on a collodion-covered microscope screen. The specimen, after drying in a desiccator, was shadowed with uranium before mounting it in the electron microscope for observation.

Since mineral allocation based on the results of the above methods is of higher category when accompanied by the data on the chemical composition of the specimens, the elemental compositions

of two representative samples were determined using the modified semimicrochemical methods of Corey and Jackson (1953).

RESULTS AND DISCUSSION

Extractable iron oxides and particle size distribution. The amount of extractable iron oxides in the samples decreased with depth except that of Guimbalaon clay which did not show any definite trend of result (table 2).

The particle size distribution of Lipa clay loam and Guadalupe clay decreased from the surface to the lower horizons. Baao clay diminished its amount of sands and silts with depth while the amount of clays increased from 67.63 to 94.46 per cent. On the other hand Guimbalaon clay indicated no definite trend of the distribution of the soil fraction with the depth.

X-ray diffraction analysis. The X-ray pattern of Lipa clay loam is characterized by a broad basal spacing in the region of 18A (fig. 1). In the Mg-saturated specimen (fine clay), indistinct basal spacings of 19.2A, 13.6A, 10.4A and 7.3A are suggested. On heating the K-saturated specimen to 400°C, slight 12.6A and 12.2A spacings were resolved. At 500°C, the 7.3A spacing disappeared and only 10.8A spacing remained. These results suggested the presence of halloysite and of interstratification of montmorillonite-vermiculite-illite and intergradational vermiculite-chlorite. The persistence of 10.8A spacing confirmed the existence of complex interstratification probably including some chlorite and possibly some illite. The enhancement after heating of 3.62A (004 of 14A) and of 3.36A (003 of 10A) proved the presence of montmorillonite-vermiculite-illite and chlorites, respectively. The presence of a large amount of layer silicates was firmly established by the random powder x-ray patterns. Strong lines were obtained at spacings of 4.46A, 4.14A, 1.49A and 1.45A. These intensities were far in excess of the layer content suggested by the parallel orientation results. Feldspar and cristobalite were also identified.

The x-ray diffraction patterns of the clay fractions and fine silt of the surface and lower horizons were similar to one another (fig. 1a).

The x-ray diffraction patterns of Guadalupe fine clay, like those of Lipa, show indistinct basal peaks (fig. 2). The qualitative x-ray diffraction analysis suggested the presence of montmorillonite interstratified with chlorite, vermiculite and illite, as shown by a plateau

TABLE 2.—*Extractable iron oxides and particle size distribution*

DEPTH IN INCHES	EXTRACTABLE IRON OXIDES %	SAND	SILT				CLAY			
		>50μ %	50-5μ %	20-5μ %	5-2μ %	TOTAL % 50-2μ	2-.2μ %	.2-0.08μ %	<0.08μ %	TOTAL % <2μ
Lipa clay loam. Batangas and Laguna, S. Luzon										
0-6	0.62	15.72	9.35	25.40	3.63	38.38	14.97	10.79	19.71	45.28
Below 36	0.16	54.41	11.46	14.32	6.97	32.75	4.01	8.81		12.82
Guadalupe clay. Rizal, Cavite, and Batangas, S. Luzon										
0-6	1.13	17.45	14.51	21.00	0.03	35.54	15.57	8.91	21.39	45.87
6-12	0.81	15.33	13.82	18.36	2.03	34.21	12.52	37.13		49.65
12-18	0.51	49.47	8.70	15.66	3.77	28.13	5.52	16.36		21.88
18-36	0.34	59.33	10.92	11.85	2.53	25.30	4.07	10.95		15.02
Below 36	0.08	72.53	10.52	6.97	1.74	19.23	1.79	6.34		8.13
Baao Clay. Albay. S. Luzon										
0-6	0.47	17.74	4.85	8.41	0.90	14.16	8.07	31.51	28.05	67.63
Below 18	0.40	3.31	1.00	0.71	0.13	1.84	10.56	83.90		94.46
Guimbalaon clay. A latosol (Cline). Occidental Negros, Visayan Islands										
0-15	2.02	8.61	5.70	20.40	1.24	27.34	18.95	34.99	8.09	62.03
15-40	3.46	4.91	3.49	12.68	4.27	20.44	15.89	55.30		71.19
Below 50	2.06	28.74	9.38	17.97	6.48	33.83	16.17	19.26		35.43

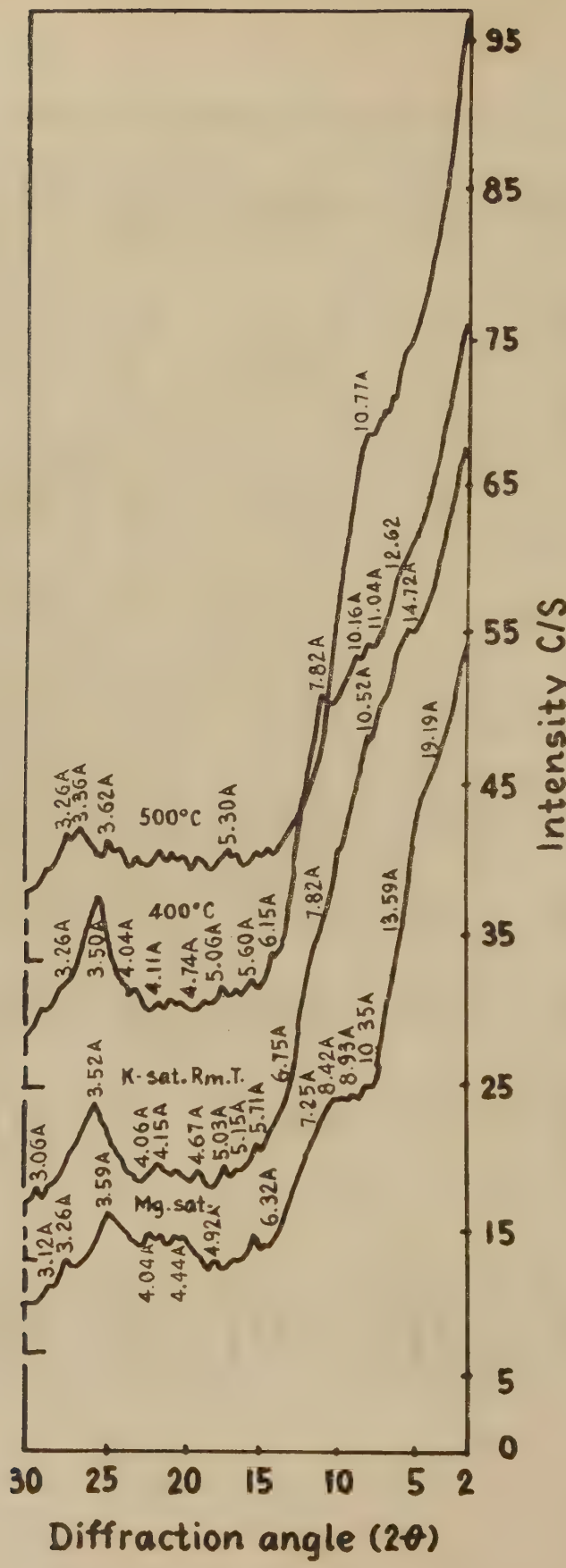

Fig. 1.—Lipa clay loam, 0–6″
Fine clay, < 0.08μ

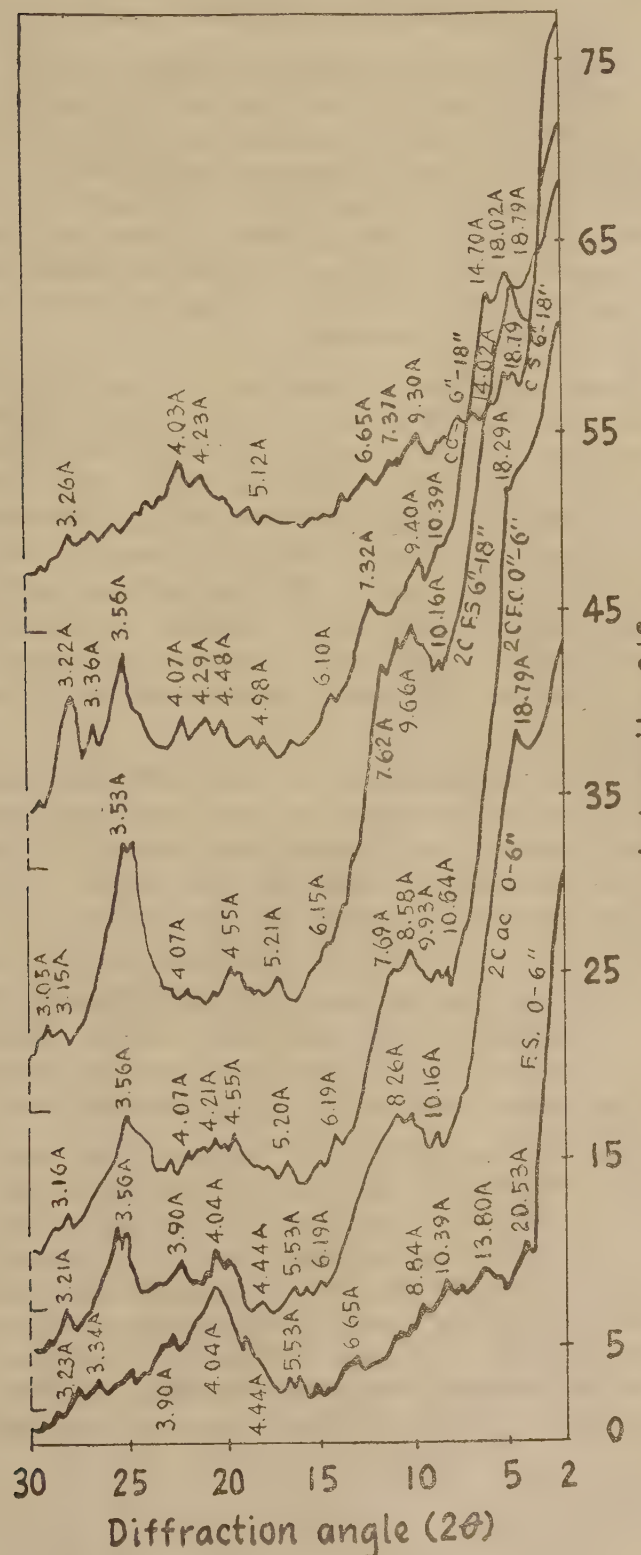

Fig. 1a.—Comparison of Lipa soil fractions of the different horizons, 0–6" and below 24" Mg-saturated.

in the region of 18A in the Mg-saturated specimens. A high multiple peak at 3.49A (002, 003, 004, 005) and the existence of 10.8A after heating at 500°C support the suggestion. The (003) of 10A at 3.32A developed after heating confirmed montmorillonite, vermiculite and illite. Persistence of 14A (004) = 3.37 and low 10A resolution confirm chlorite. Interstratification is further supported by strong lines at 7.35A, 4.50A, 2.39A and 1.47A in the powder pattern (fig. 2a). These established the presence of major amounts of layer silicates. Feldspar was also identified.

In the Mg-saturated fine clay specimen of Baao clay, obscure basal spacings of 18.8A, 10.2A, 8.06A and 7.62A are indicated (fig. 3). The K-saturated specimen, heated at 400°C, shows 10.8A and 7.89A. However, only 10.5A persists at 500°C. This indicates the presence of halloysite, illite and interstratified montmorillonite-vermiculite-illite and also chlorite. The persistence of 3.67A (004 of 14A) and 3.34A (003 of 10A) after heating confirms chlorite and illite, respectively. Strong lines at spacings of 4.61A, 4.26A, 2.61A, 1.77A, 1.64A and 1.48A prove the presence of layer silicates, feldspar and cristobalite. The lower horizon is similar to the surface horizon (fig. 3a).

From the foregoing discussions, it is concluded that, according to the x-ray diffraction methods, Lipa clay loam, Guadalupe clay and Baao clay contain montmorillonite as the dominant layer silicate with some interstratification of vermiculite-chlorite-illite. Halloysite and kaolinite, feldspar and cristobalite are also present.

The indistinct basal spacing of these clays in the region of 18A are interpreted as (1) indicating complex interstratification, (2) suggesting lack of optimum crystalline structure, and (3) allowing the presence of some intimately mixed amorphous materials (Guadalupe fine clay specific surface was 180 per cent of montmorillonite).

The x-ray diffraction patterns of Guadalupe clay show comparatively more distinct basal spacing than Guadalupe clay particularly in the region of 1:1 layer silicates. The Mg-saturated specimen shows respectable 7.43A spacing although its 20.5A is as indistinct as that of Guadalupe, suggesting that some materials which cause the broadening of the x-ray diffraction are present (fig. 4). On heating the K-saturated specimen at 400°C, the spacing of 7.13A became 7.19A; this spacing disappeared completely at 500°C. The presence of 14.02A in both the Mg- and K-saturated specimen indi-

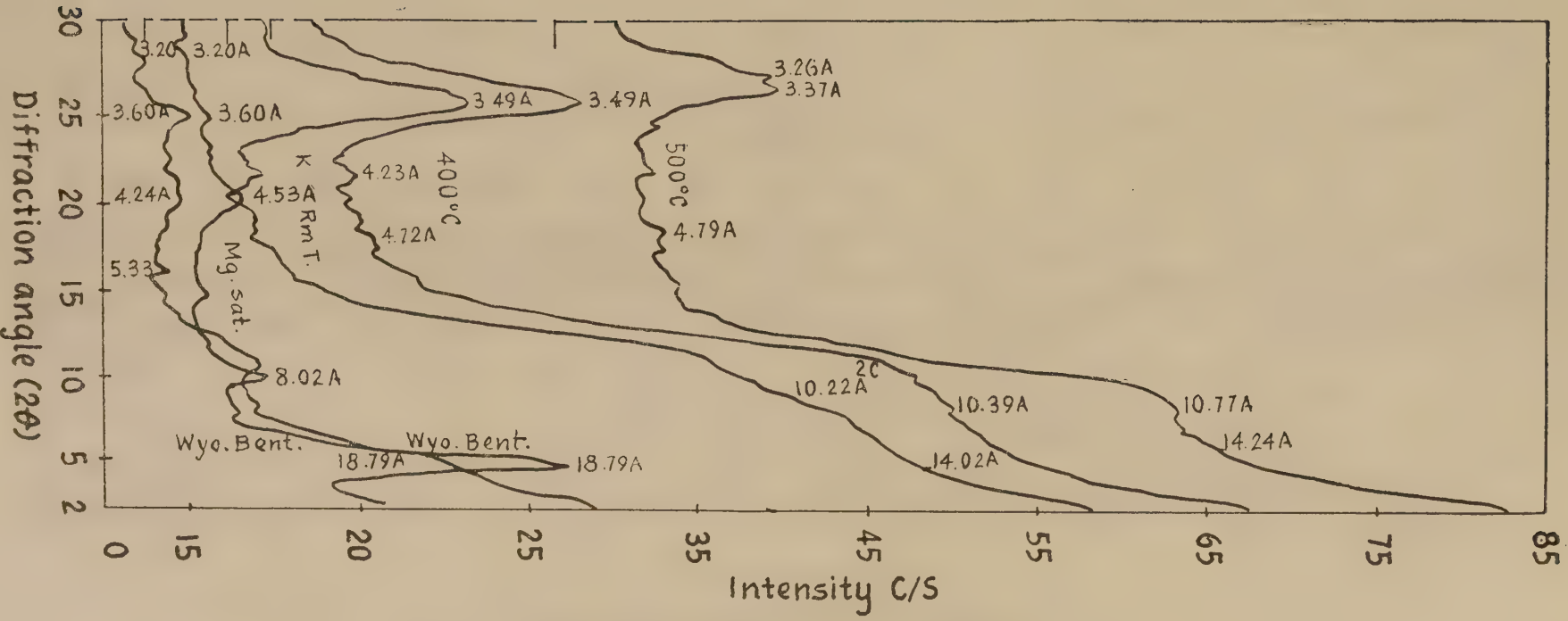

Fig. 2.—Guadalupe clay, 0–6″; Fine clay, $< 0.08\mu$ with Wyo. Bentonite.

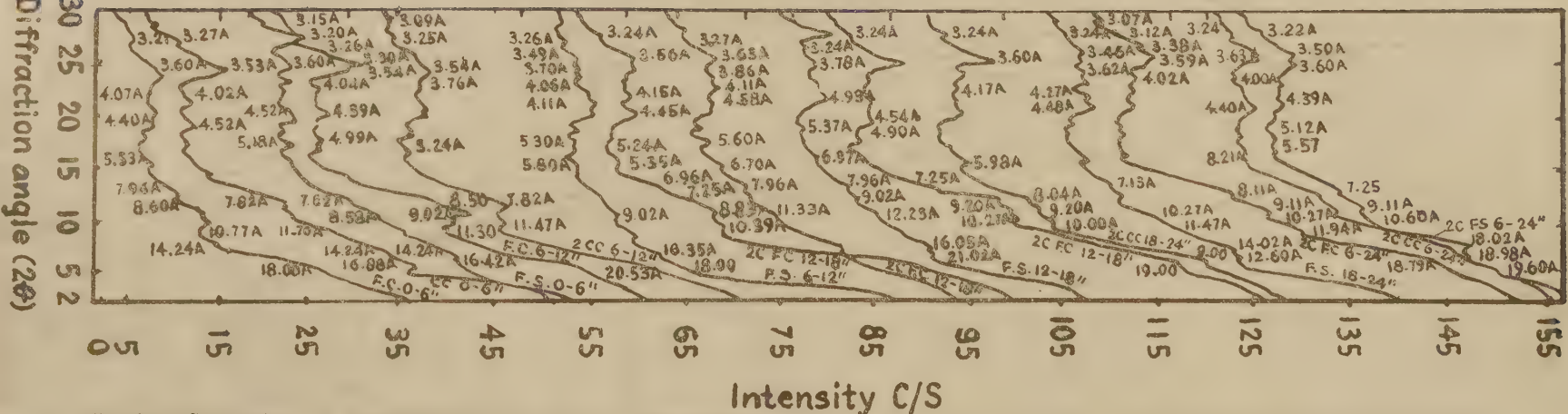

Fig. 2a.—Comparison of Guadalupe soil fractions of the different horizons, 0–6", 6-12", 12–18", 18–24" and below 24" Mg-saturated.

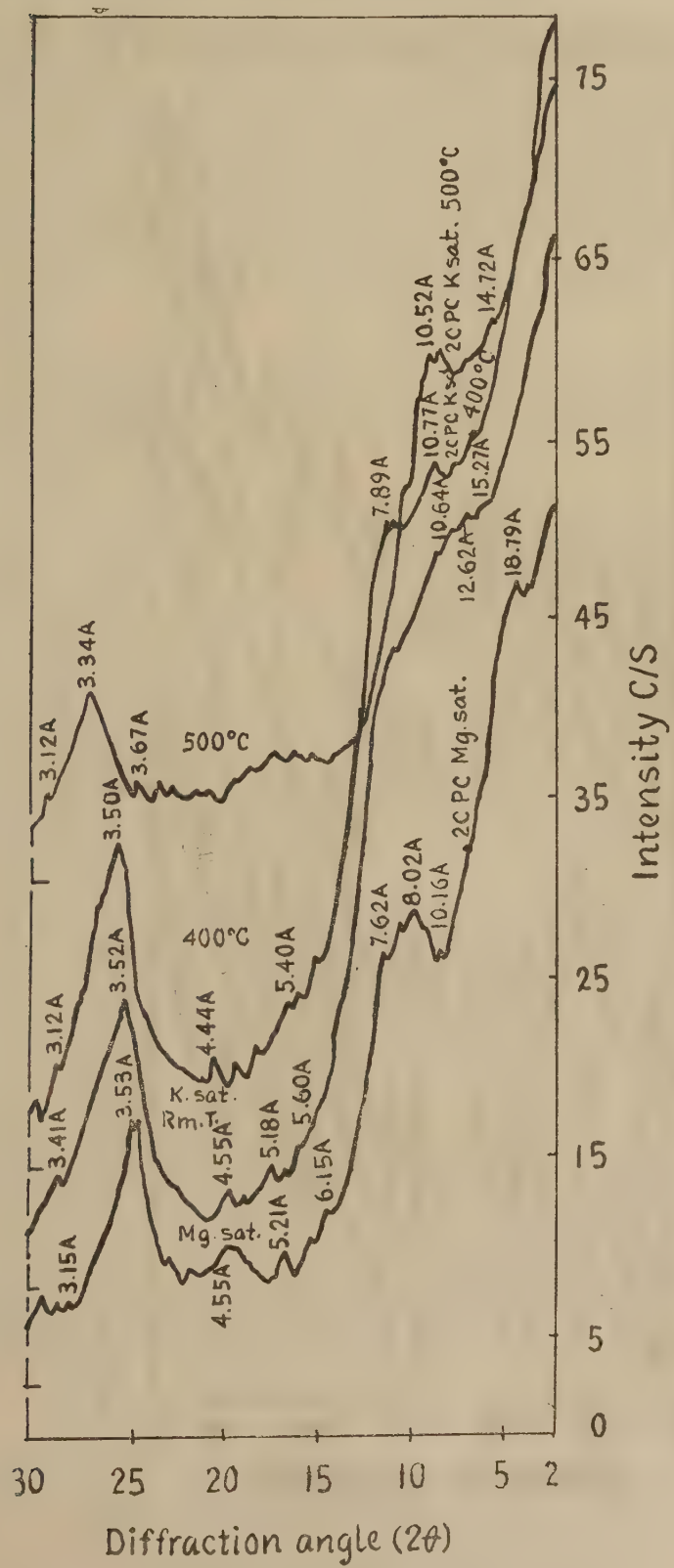

Fig. 3.—Baao clay, 0–6"; Fine clay, < 0.08μ

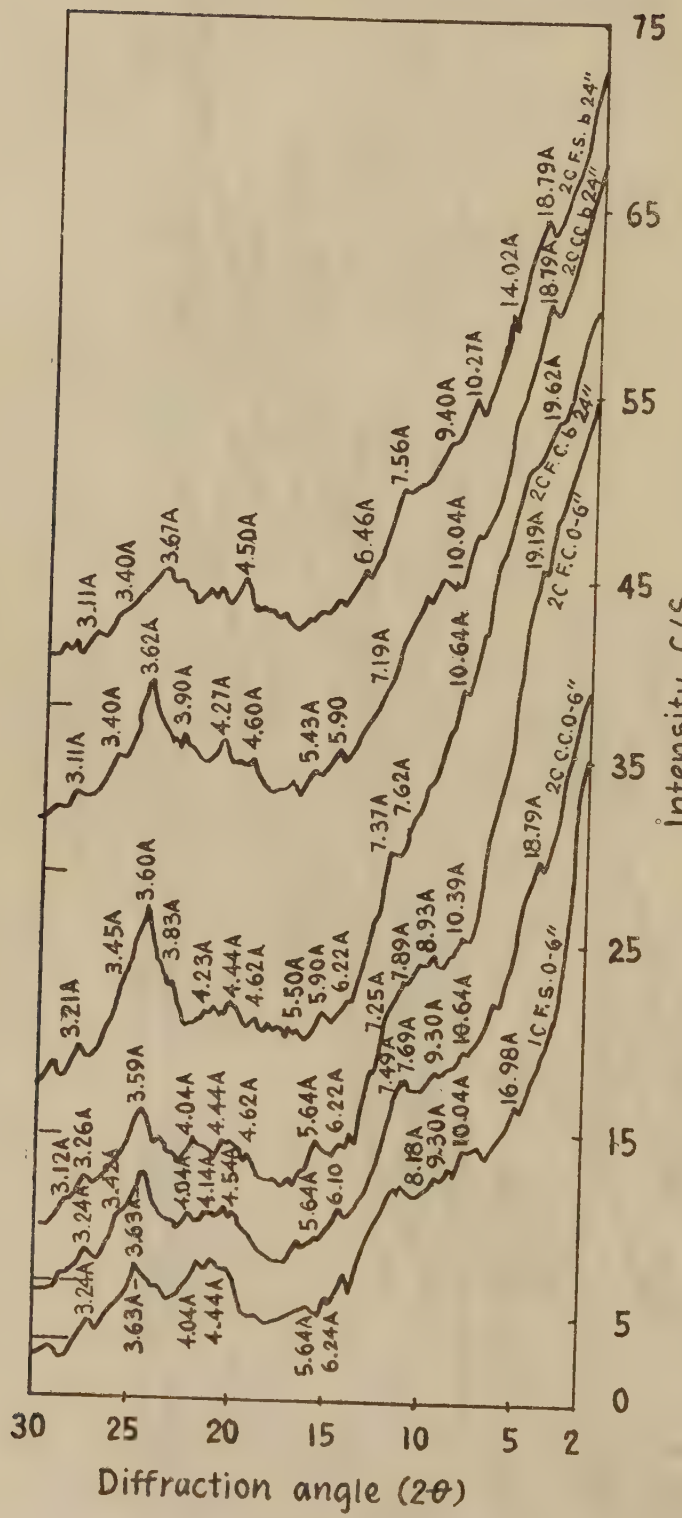

Fig. 3a.—Comparison of Baao soil fractions of the different horizons, 0–6" and below 18" Mg-saturated.

cates either chlorite or vermiculite or both. On heating to 500°C, it persisted proving the presence of chlorite. The existence of 10.4A with Mg-saturation pattern and with the K-saturation before heating indicates the presence of illite with some interstratification of wider spacings (Hendricks and Teller, 1942). This is further sustained by the persistence of 10.2A after heating at 500°C. Feldspar and cristobalite exhibited relatively intense peaks. Gibbsite is also present. Strong lines in the spacings of 7.02A, 4.41A and 3.84A in the powder pattern confirm halloysite with illite and chlorite (fig. 4a).

The x-ray diffraction patterns of the surface and the lower horizons are similar to each other. This is true not only of the clay fractions but also of the fine silt (fig. 4b). The fine silt showed very strong 4.06A, cristobalite peak.

A comparative study of the x-ray diffraction patterns indicated that the fine clay fractions of Lipa clay loam, Baao clay and Guadalupe clay, which have been found to be identical to the diffraction patterns of their corresponding lower horizons, have each a broad basal spacing in the region of 18A suggesting the presence of mixed layer structures (fig. 5). Hendricks and Teller (1942), Bradley (1945), Mering (1949), and Brown and MacEwan (1951) attributed the existence of broad x-ray reflections intermediate between portions for basal reflections of distinct clay mineral species and not showing an integral series of orders to the presence of mixed layer structures.

Grim (1953) stated that clay materials consisting of more than one clay mineral are capable of exhibiting a number of mixed-layer structures which undoubtedly have been missed often in clay mineral analyses. The mixture may consist of discrete particles where there is no preferred geometric orientation of one particle with respect to its neighbors or where there may be an interstratification of the layer clay minerals in which the individual layers are of the order of a single or a few alumino-silicate sheets. Regular interstratification is stacking along the C axis with regular repetition of the different layers. Its unit cell is equivalent to the sum of the component layers with an integral series of (001) reflections. Chlorite structure simulates this stacking. Random interstratification has no uniform repetition of layers. This occurs commonly in the mixed layers of illite and montmorillonite and montmorillonite and chlorite. In the case of

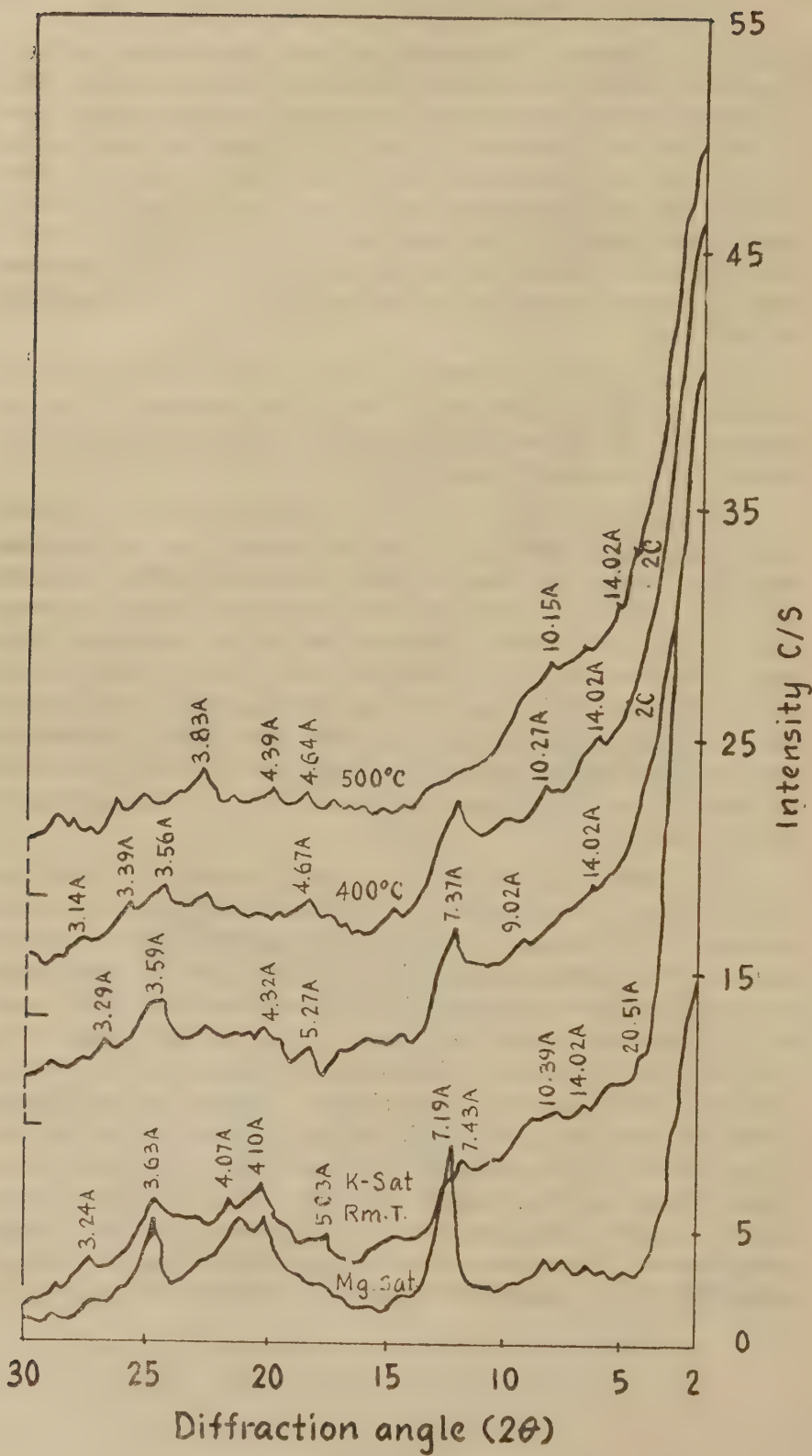

Fig. 4.—Guimbalaon clay, 0–15"; Fine clay, < 0.08μ with Merck-Kaolinite.

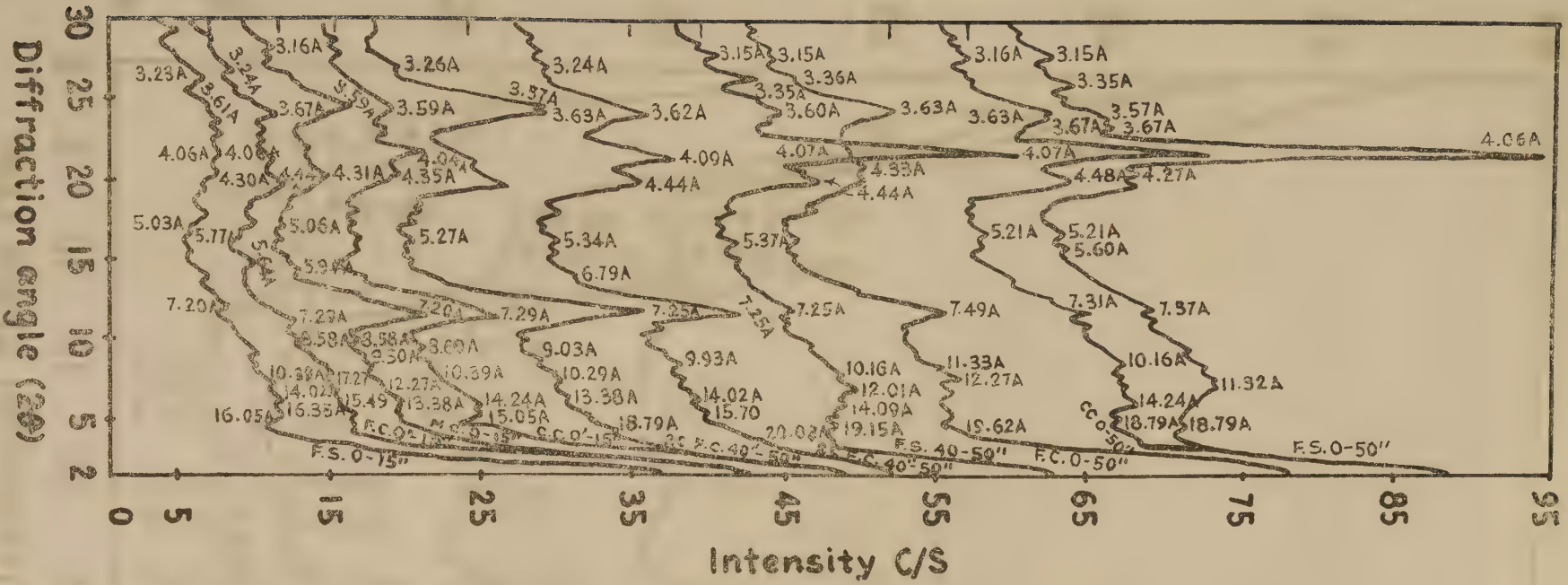

Fig. 4a.—Comparison of Guimbalaon soil fractions of the different horizons, 0–15", 40–50" and below 50" Mg-saturated.

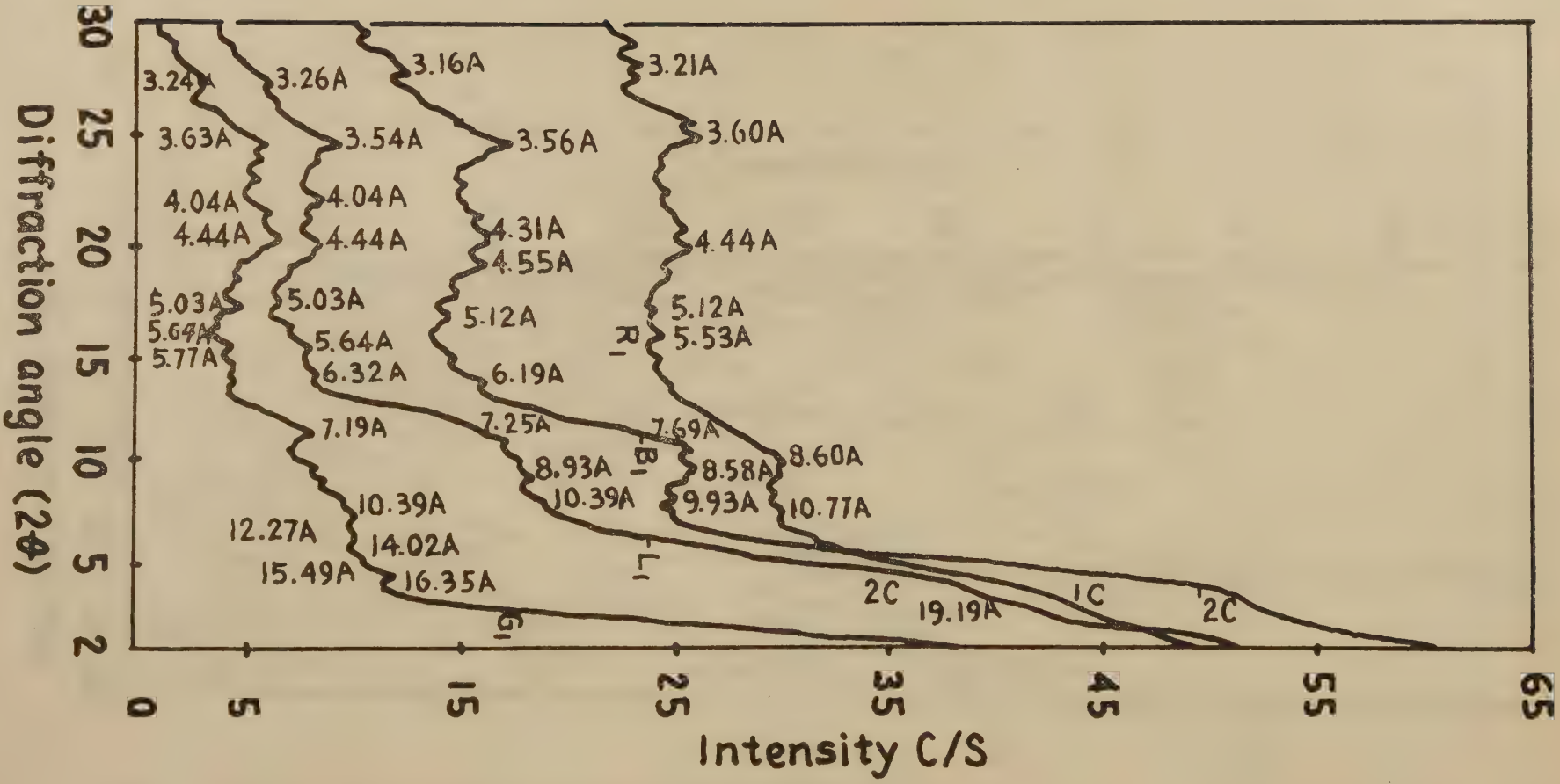

Fig. 5—Comparison of 0–6″ layer of Lipa clay loam, Guadalupe clay, Baao clay, and Guimbalaon clay. Fine clay, < 0.08μ Mg-saturated.

R_1—Guadalupe clay
B_1—Baao clay
L_1—Lipa clay loam
G_1—Guimbalaon clay

illite and kaolinite, there would be a variation in the silicate layers themselves.

Guimbalaon clay showed in addition to a broad reflection in the region of 18A, a distinct peak in the region of 7.2A indicating strongly that the dominant clay mineral in Guimbalaon clay was quite distinct from that in Lipa clay loam, Baao clay, and Guadalupe clay.

Dehydration analysis

The dehydration data show that there is only very slight reaction at a temperature range from room temperature to 110°C, the loss of sorbed water being only 2 per cent (table 3).

Similar trend of reaction is also indicated in the region of 110-350°C. The loss in weight in 2.67 per cent for Guadalupe and 2.02 per cent and 2.70 per cent for Guimbalaon fine clay and medium clay, respectively. This very slight reaction is attributed to the presence of allophane-like materials in the specimens.

TABLE 3.—*Loss in weight of Guadalupe and Guimbalaon clay*

TEMPERATURE RANGE °C	GUADALUPE CLAY 0-6″ <0.08μ per cent	GUIMBALAON CLAY 0-15″	
		<0.08μ per cent	0.08-0.2μ per cent
25–110	2.05	1.97	2.43
110–350	2.67	2.02	2.70
350–450	8.38	12.57	13.39
450–540	10.00	13.51	14.68
540–900	12.83	17.53	14.70

At a range of 350-450°C, the reaction is accelerated, and Guadalupe showed a loss of OH ion of 6 per cent over the lower temperature while Guimbalaon, 13 per cent. This indicates strongly that the dominant minerals in the two soils are dissimilar, the former being slow-reacting whereas the latter, fast-reacting.

In the region of 450-540°C and 540-900°C, Guadalupe still continues its reaction but at a much lower rate than that in the preceding temperature, the average decrement of OH ion for each temperature being only 2 per cent. Guimbalaon fine clay shows at these two temperature ranges, 1 and 4 per cent dehydration loss, respectively. These results sustain further the fact that dominant minerals in the

two soils are not similar. On the other hand, Guimbalaon medium clay already shows a complete reaction at 450-540°C which would mean that mineral content is more strongly halloysitic than its fine clay which continuously decreased its weight. This behaviour of fine clay could be attributed to the presence of some montmorillonite.

The loss of 10 per cent and 14 per cent sorbed water in Guadalupe and Guimbalaon soils from 110°C to 900°C, respectively, coincides with the findings that allophane lost 10-15 per cent of its weight on dehydrating above 110 to 1000°C (Ross and Kerr, 1934). Halloysite loses a similar amount and montmorillonite somewhat less.

Differential thermal analysis

The differential thermogram of Guadalupe fine clay (<0.08 micron) indicates its first endothermic reaction at 140°C, which might be attributed to montmorillonite-illite-vermiculite-halloysite (fig. 5). At 400°C, the very intense exothermic reaction is due to the organo-mineral complex. This is confirmed by the disappearance of the peak when the specimen was treated six times with 30 per cent H_2O_2 before subjecting it to the analysis (fig. 6). The endothermic reaction at 535°C is in the neighborhood of kaolinite peak suggesting its presence. The third endothermic reaction is at 770°C. This peak is attained only after a series of comparatively consistent rate and temperature reaction, whose beginning and end are both obscure. This peak coincides with that of antigorite. An indistinct exothermic peak is indicated at 900°C which could be attributed to montmorillonite.

In connection with the non-appearance of a sharp montmorillonite endothermic peak in the higher temperature region, the work of Mackenzie (1950), wherein he reported that montmorillonite in a mixture of minerals may give little or no thermal reaction even if its x-ray spectrum is completely diagnostic, is cited.

The first endothermic reaction in Guimbalaon medium clay (0.08-0.2 micron) is indicated at 140°C. This could be the resultant reaction of halloysite-montmorillonite-illite-vermiculite. A very distinct endothermic peak at 560°C is highly suggestive of the presence of a dominant amount of halloysite in Guimbalaon clay. The exothermic reaction at 948°C, which is a little bit lower than the value previously established, is attributed to the dilution of halloysite with some other soil minerals.

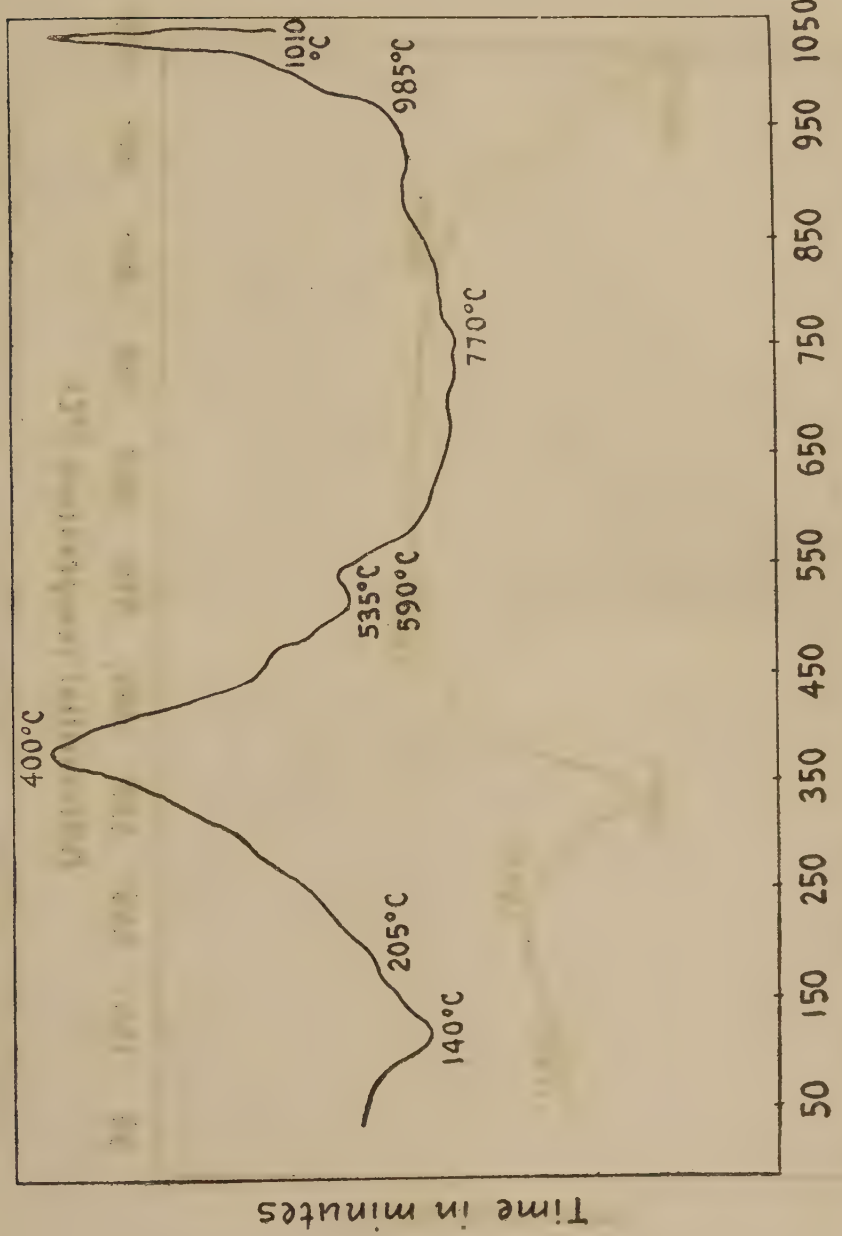

Fig. 6.—DTA–Guadalupe, 0–6″ fine clay, $< 0.08\mu$ before extra treatment with 30% H_2O_2.

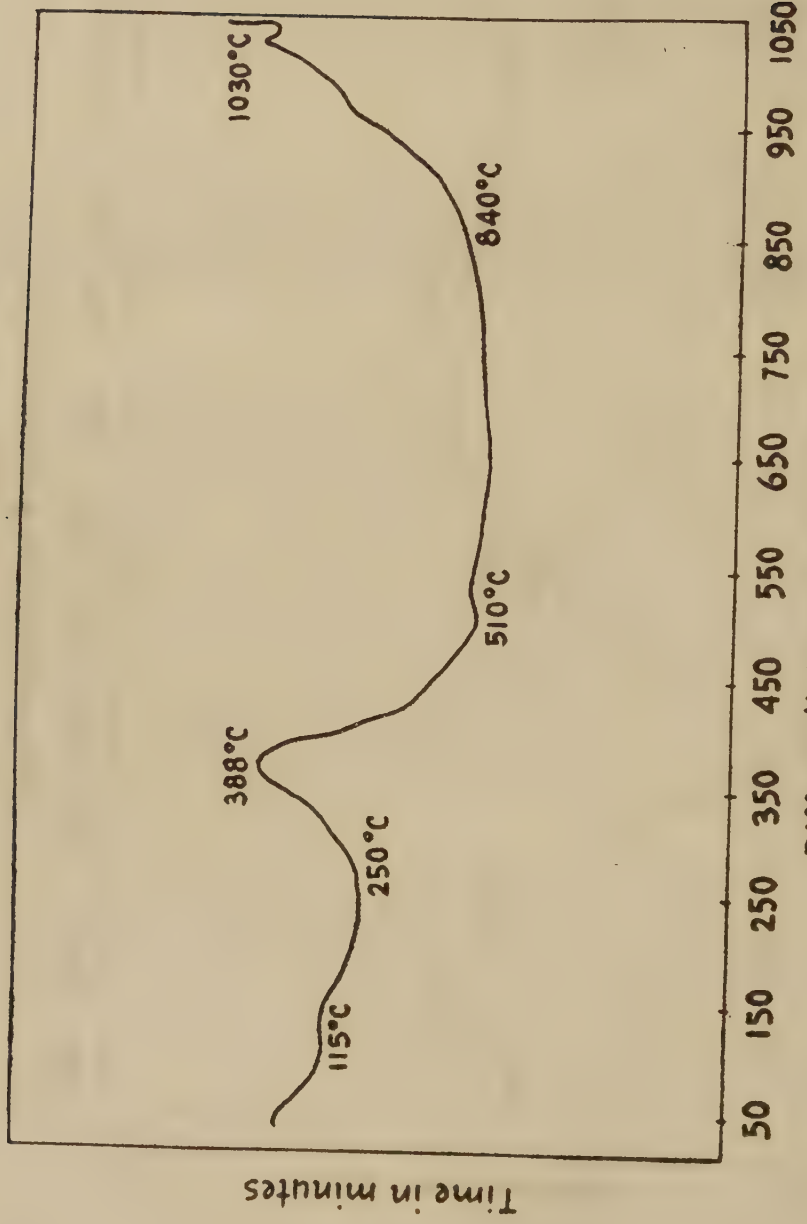

Fig. 6a.—DTA–Guadalupe, 0–6″ fine clay, <0.08μ after extra treatment with 30% H_2O_2.

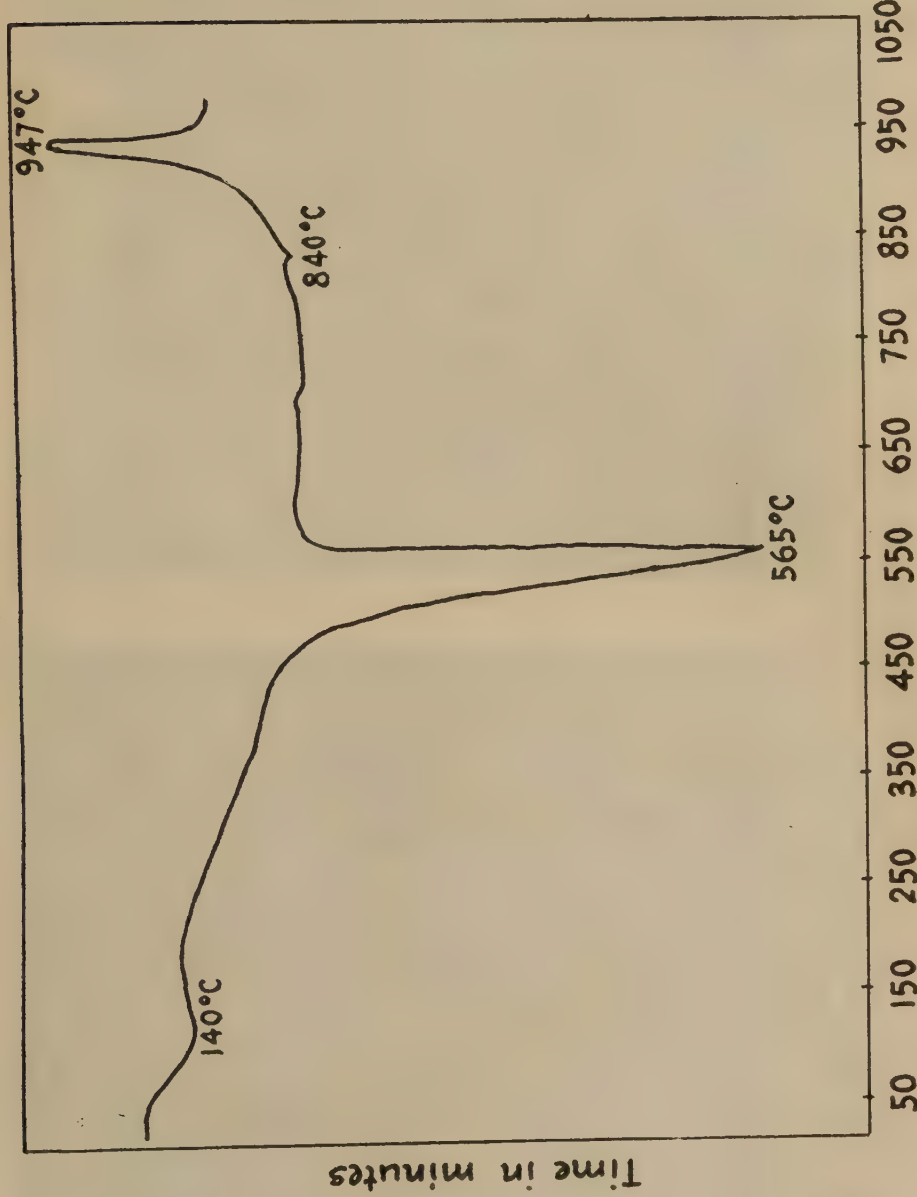

Fig. 6b.—DTA–Guimbalaon, 0–15″ medium clay, 0.08–0.2μ.

Chemical analysis

The chemical composition of Guadalupe clay is not at all similar to Guimbalaon (table 4).

TABLE 4.—*Chemical composition of Guadalupe and Guimbalaon clay*

CONSTITUENT	GUADALUPE CLAY 0-6″ <0.08μ per cent	GUIMBALAON CLAY 0-15″, 0.08-0.2μ per cent
SiO_2	47.00	42.70
Al_2O_3	23.30	38.40
Fe_2O_3	12.20	1.87
FeO_2	1.37	0.32
TiO	2.19	0.94
CaO	1.80	0.17
MgO	2.00	0.12
K_2O	0.34	0.18
Na_2O	0.70	0.70
$H_2O < 350°C.$	2.67	2.70
$H_2O > 350°C.$	5.91	11.98
SiO_2/Al_2O_3	3.4/1	0.95/1

With the exception of Al_2O_3 and H_2O, the amounts of the different oxides in Guadalupe clay are higher than those in Guimbalaon clay. The ratio of SiO_2:Al_2O_3 in Guadalupe is 3.4:1 indicating that the soil is montmorillonitic. The relatively high amounts of Fe_2O_3 and MgO support the existence of 2:1 layer silicate in Guadalupe and indicate that the montmorillonite is Fe-Mg-Montmorillonite (non-tronite).

On the other hand the chemical composition of Guimbalaon clay shows a close parallelism to the chemical composition of halloysite (Grim, 1953). The ratio of SiO_2:Al_2O_3 being 0.95:1, the existence of a 1:1 layer silicate in Guimbalaon clay is concluded.

The electron micrographs of Guadalupe clay (fig. 7) exhibit fluffy masses of particles which are similar to the characteristics of montmorillonite (Grim, 1953).

On the other hand, Guimbalaon clay shows elongated tubular particles which are identical to Grim's description of halloysite (fig. 8).

Guadalupe fine clay $<0.08\mu$
Magnification 5900 X

Guadalupe medium clay, $0.08–0.2\mu$
Magnification 5900 X

Fig. 7. - Electronmicrographs

Guimbalaon fine clay, $<0.08\mu$
Magnification 5900 X

Guimbalaon medium clay, 0.08–0.2μ
Magnification 5900 X

Fig. 8.—Electronmicrographs

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The physical emphasis of modern science, its passion for laboratories and experiments, its tendency to seek mathematical and quantitative formulas for all phenomena have left it helpless in dealing with such elusive (if not always intangible) realities as beauty; not till the biological approach finds further acceptance in psychology will the aesthetic problem fall into its proper place.

—*W. J. P. Durant*

* * *

Experiment, directed by the disciplined imagination either of an individual or, better still, of a group of individuals of varied mental outlook is able to achieve results which far transcend the imagination alone of the greatest philosopher.

—*Lord Rutherford*

PHYLLOSTICTA LEAF SPOT AND FRUIT ROT OF EGGPLANT [1]

VENUS S. CLOMERA

WITH SEVEN TEXT FIGURES

Leaf spot and fruit rot of eggplant is a minor disease caused by *Phyllosticta hortorum* Speg. Lesions on the leaves are circular or irregular, brown, with grayish center where pycnidia are produced. Infection may be forced on the fruits in different stages of development. The areas around the wounds become brownish with dark brown edges. Pycnidia are produced later in the inner brownish area.

The fungus is easily isolated by the tissue culture method. It produces abundant pycnidia on potato-dextrose agar, potato-sucrose agar, oatmeal agar, onion agar, eggplant decoction agar, malt agar and nutrient dextrose agar. Its pycnospores may remain viable for eight months in the agar medium.

Of the eggplant varieties tested, only Long Native Purple showed slight susceptibility to the disease. Cross-inoculation showed that tomato may serve as alternate host of the fungus. The disease may be controlled by fungicides and sanitation in the field.

In August, 1954, Quiamco [2] observed the leaf spot of eggplant in the experimental plot of the Department of Agronomy. Microscopic examinations of specimens submitted to the Department of Plant Pathology revealed pycnidia and pycnospores characteristic of *Phyllosticta*.

Since information about the disease and its causal fungus is very limited, this study was conducted from December, 1954, to January, 1956, in the laboratory of the Department of Plant Pathology and in the vegetable gardens in the College and vicinity (1) to study the morphological and physiological characteristics of the causal fungus, (2) to determine the relation of the causal fungus to *Phomopsis vexans* (Sacc. and Syd.) Harter, a more prevalent and serious disease of eggplant, and (3) to formulate control measures.

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[1] Central Experiment Station Contribution No. 1940. Thesis presented for graduation, with the degree of Bachelor of Science in Agriculture from the College of Agriculture, March, 1956. Prepared in the Department of Plant Pathology under the direction of Dr. Faustino T. Orillo and Prof. Victoria M. Ela.

[2] P. V. Quiamco, "Mass screening of eggplant for fruit rot resistance." (Thesis presented for graduation with the degree of Bachelor of Science in Agriculture from the College of Agriculture, 1955. Unpublished.)

GEOGRAPHICAL DISTRIBUTION OF THE DISEASE

According to Harter (1914), the disease of the leaf and fruit of the eggplant, commonly attributed to *Phyllosticta hortorum*, a fungus identified by Spegazzini in 1881 as occurring on the leaf, has been known to plant pathologists in the United States and in certain parts of Europe.

The occurrence of leaf spot and fruit rot of eggplant in Southern China was attributed to this fungus by Reinking (1919). In the Philippines the fungus, along with others, such as *Colletotrichum sp.*, *Gloeosporium melongenae* Sacc. and *Phytophthora parasitica Dastur*, was also mentioned by Ocfemia (1925) on the fruits of eggplant.

This disease of the leaf and fruit of eggplant was briefly described by Duggar (1909) and by Stevens (1913). The fungus was reported on tomato leaves by Ellis and Everhart (1900).

Palo (1936), in his study of the Phomopsis disease of eggplant, first believed the disease to be due to *Phyllosticta hortorum* Speg.

SYMPTOMS

Infection manifests itself on the old lower leaves as circular to irregular brownish spots with grayish center and brown border (fig. 1). Black specks which are the fruiting structure or pycnidia of the fungus developed in the brownish gray center. In some cases a few of the spots fell off, forming shot holes.

Fruits of eggplant in all stages of their development were infected by the disease during artificial inoculation experiments when they were wounded or pricked and lengthily subjected to damp chamber conditions. The rotted portions were sunken and brownish, with dark brown edges. Minute black specks later developed in the inner brownish area.

No symptom was observed on the blossoms, main stem, and branches of the plant.

THE CAUSAL ORGANISM

Sections from the outer portions of the typical leaf spots were disinfected with 1:1000 mercuric chloride solution for 30 to 35 seconds, washed in three changes of sterile distilled water, and planted on the surface of plated potato-dextrose agar. When growth appeared after two or three days, transfers were made to sterile

Fig. 1.—Eggplant leaves showing advanced symptoms of the disease caused by *Phyllosticta hortorum* Speg. (× ¼) (*Photograph taken by the Photographic Division.*)

potato-dextrose agar slants. The pure cultures thus obtained were used in the studies of the morphology, cultural behavior, and pathogenicity of the fungus.

MORPHOLOGY

Mycelium. The fungus produces abundant mycelium on most agar media and sterilized plant tissues. The hyphae when young are thin-walled and hyaline. With age they are much branched, septated and grayish, with their walls becoming thicker and their contents denser than when young (fig. 2). Measurements of 200 hyphal cells from 10-day-old cultures on potato-dextrose agar showed that the cells vary from 5.19 to 33.32 microns in length and from 1.87 to 6.9 microns in width, the average size being 14.5 ± 0.32 by 4.20 ± 0.07 microns.

Pycnidia. The pycnidia are globose-lenticular, thin-walled, membranous, light brown when young, and dark brown when mature. They are ostiolate but not beaked (fig. 3A). The ostioles range from 9.99 to 19.98 microns. Pycnidia occur singly in most cases. Occasionally two or more of them merge together, so that two or more

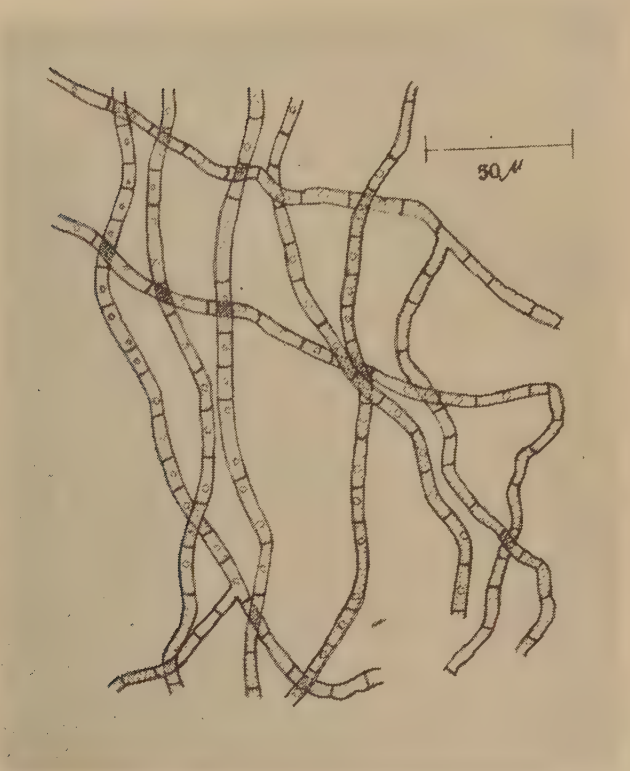

Fig. 2.—Camera lucida drawing of the mycelium of *Phyllosticta hortorum* Speg. from 15 day-old potato-dextrose agar culture (× 430). (*Photograph taken by the Photographic Division.*)

ostioles can be observed. When a pycnidium is broken up, simple, short and delicate conidiophores may be seen (fig. 3B). The pycnospores are borne singly on the tips of these conidiophores. Measurements of 200 pycnidia from 10-day-old cultures on potato-dextrose agar showed that the diameters range from 53.28 to 164.84 microns, with an average of 103.38 ± 1.65 microns.

Pycnospores. Pycnospores which are abundantly produced in the pycnidium are extruded from the ostiole in the form of a gelatinous ribbon (fig. 4). They are held together by a mucilaginous substance which readily dissolves in water. The pycnospores are thin-walled, hyaline, continuous, ellipsoid to elongate, rounded at both ends and usually with two oil droplets (fig. 5A). Upon ger-

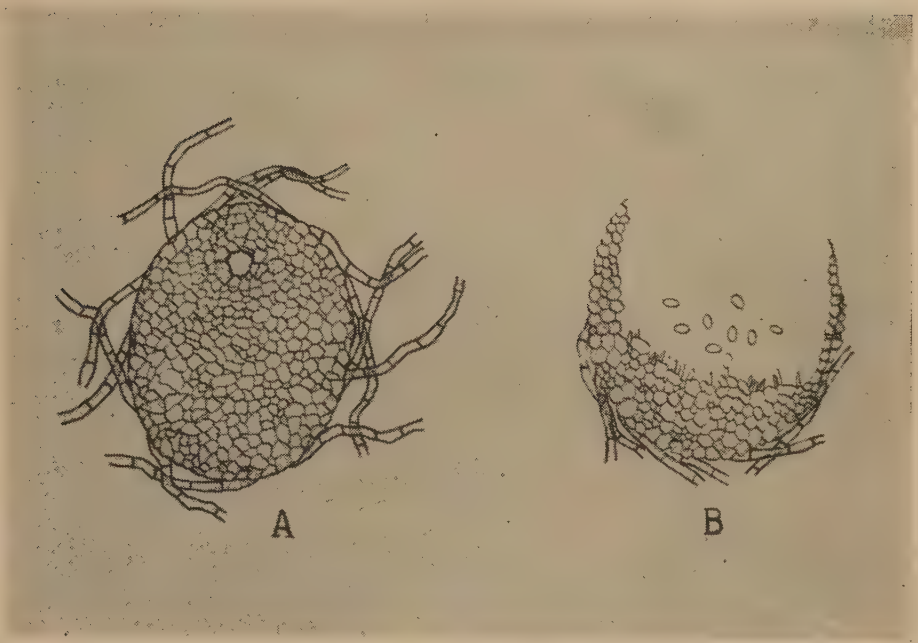

Fig. 3.—Camera lucida drawings of (A) mature pycnidium of *Phyllosticta hortorum* Speg. from 10-day-old potato-dextrose agar culture, and (B) section of a pycnidium showing the arrangement of conidiophores with some pycnospores (× 430). (*Photograph taken by the Photographic Division.*)

mination, one germ tube is produced at one end; very seldom are two germ tubes produced from each end of the conidium (fig. 5B). Measurements of 200 pycnospores from 10-day-old cultures on potato-dextrose agar showed that they vary from 4.20 to 9.45 microns in length and 2.31 to 5.46 microns in width, with an average size of 5.91 ± 0.065 by 3.33 ± 0.046 microns.

PHYSIOLOGY

Growth and pycnidial production of the fungus on various agar media and substrates. The growth, cultural characteristics, and pycnidial production of the fungus were observed at laboratory temperature (27-28°C) on twelve different agar media, namely: potato-dextrose agar, potato-sucrose agar, oatmeal agar, onion agar, malt agar, nutrient agar, nutrient-dextrose agar, corn meal agar, bean agar, Czapek's agar, eggplant-decoction agar, and water agar. Triplicate cultures in Petri dishes were made for each medium.

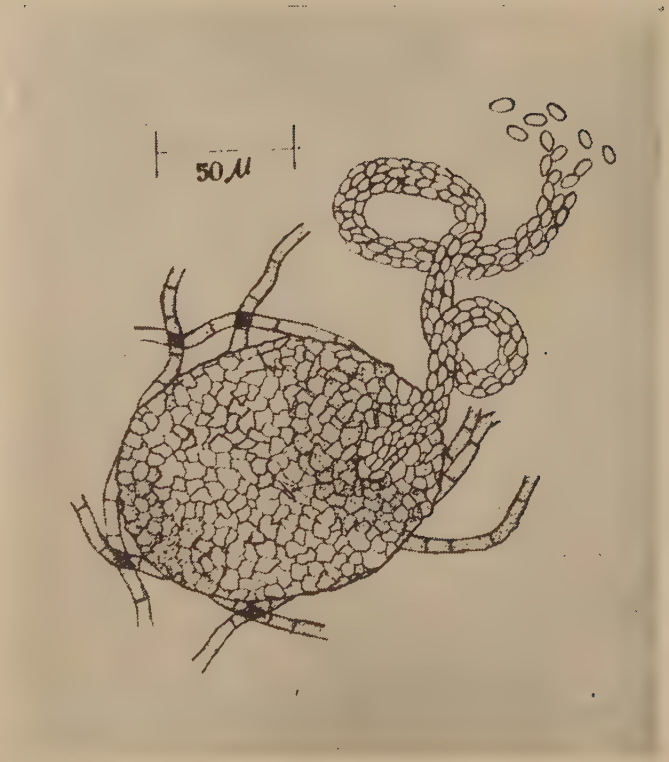

Fig. 4.—Camera lucida drawing of a mature pycnidium of *Phyllosticta hortorum* Speg. from 5-day-old potato dextrose agar culture showing the liberation of pycnospores through the ostiole. (*Photograph taken by the Photographic Division.*)

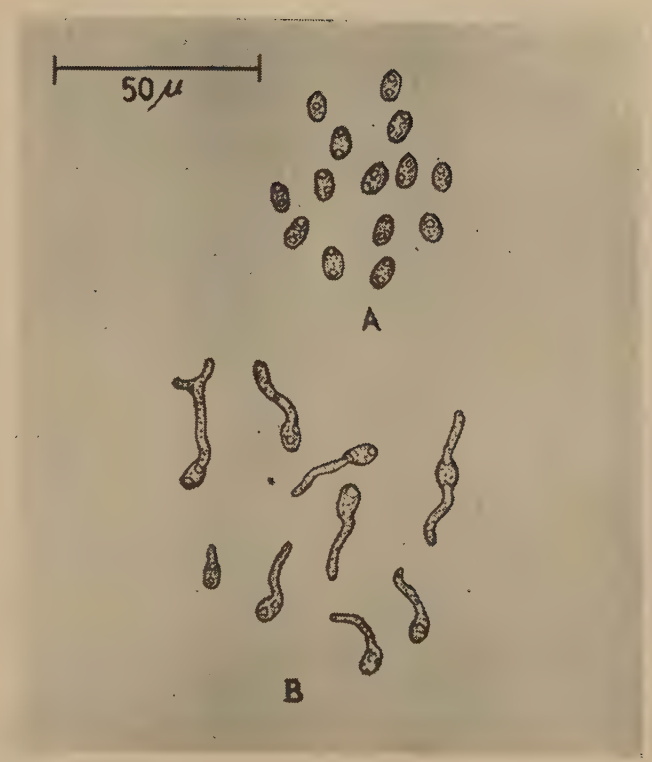

Fig. 5.—Camera lucida drawings of: (A) pycnospores (B) pycnospores germinating on tap water after 15 hours. (*Photograph taken by the Photographic Division.*)

The results are summarized in table 1. The fungus grew well on all the media except on nutrient agar where only few pycnidia and thin mycelial growth were produced. On water agar no pycnidia and very thin mycelial growth were observed. The cultural characteristics of the fungus differed in the different culture media (fig. 6).

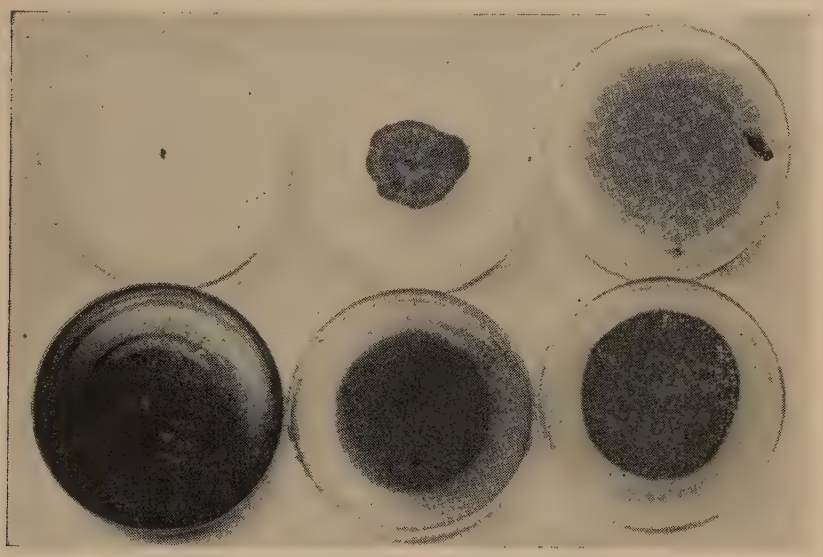

Fig. 6.—Growth and pycnidial production of *Phyllosticta hortorum* Speg. on different agar media after 7 days: 1st row, left to right, bean agar, malt agar, and potato dextrose agar; 2nd row, same order, water agar, Czapek's agar and corn meal agar. (*Photograph taken by the Photographic Division.*)

Sterilized substrates consisting of eggplant, Irish potato, gabi, radish, sincamas, papaya, pepper and cumber cylinders were inoculated with the fungus mycelium. Triplicate cultures were made for each substrate. Good growth and pycnidial production were observed in all substrates (table 1a). Pycnidia produced on the different substrates differed in size.

Growth of fungus on media of varying hydrogen-ion concentrations. To determine the effect of varying hydrogen-ion concentrations on growth and pycnidial production, the fungus was grown on potato-dextrose agar with pH from 2.5 to 10.0. The pH of the medium was adjusted to the desired level by the addition of either sterile N/20 HCl or N/20 NaOH. The pH readings were determined with the La Motte colorimeter. Triplicate cultures were made for each pH. Each test tube of agar with the adjusted pH was poured into a sterile Petri dish, spread evenly, and allowed to congeal.

TABLE 1.—*Growth characteristics and pycnidial production of* Phyllosticta hortorum *Speg. on various agar media*

MEDIUM	GROWTH CHARACTERISTICS	PRODUCTION OF PYCNIDIA	DIAMETER OF COLONY AFTER 9 DAYS [a]	AVERAGE DAILY GROWTH
			mm.	*mm.*
Potato-dextrose agar	Very abundant white to dull white aerial mycelial growth; Culture medium changed from iron gray to olivaceous black	Very abundant	83.14	10.39
Potato-sucrose agar	Very abundant whitish aerial mycelial growth produced; Culture medium fawn brown	Very abundant	81.76	10.22
Eggplant-decoction agar	Very abundant dull white aerial mycelial growth; Culture medium ochraceous buff	Very abundant	88.02	11.00
Oatmeal agar	Abundant dull white aerial mycelial growth; Culture medium easter gray	Very abundant	84.24	10.53
Malt agar	Abundant moist dull white aerial mycelium; Culture medium clow brown	Abundant	79.72	9.96
Corn-meal agar	Very abundant dull white submerged mycelium; Culture medium dark olive	Very abundant; fine pycnidia	89.9	11.23
Bean agar	Very thin whitish aerial mycelial growth; Culture medium natal brown	Very abundant; fine pycnidia	82.26	10.32
Nutrient-dextrose agar	Abundant whitish moist mycelial growth; Culture medium buffy brown	Fairly abundant	46.80	5.85
Nutrient agar	Thin whitish submerged mycelial growth; Culture medium vinaceous buff	Few	44.80	5.60
Czapek's agar	White aerial mycelial growth very thick and depressed; Culture medium olivaceous black	Very abundant	42.66	5.33
Water agar	Very very thin cottony white aerial mycelial growth			

[a] Average of three cultures.

TABLE 1a.—*Growth characteristics and pycnidial production of* Phyllosticta hortorum *Speg. on different substrates*

SUBSTRATE	RELATIVE ABUNDANCE OF MYCELIUM	PYCNIDIAL PRODUCTION	NUMBER OF PYCNIDIA MEASURED	AVERAGE DIAMETER OF PYCNIDIA
				μ
Sweet potato	Fairly abundant	Very abundant	10	131.10
Eggplant	Fairly abundant	Fairly abundant	10	145.52
Potato	Fairly abundant	Very abundant	10	123.87
Gabi	Fairly abundant	Very abundant	10	116.38
Sincamas	Very abundant	Abundant	10	75.93
Radish	Scanty	Abundant	10	89.08
Papaya	Very abundant	Abundant	10	83.95
Cucumber	Scanty	Scarce	10	71.41
Pepper	Scanty	Abundant	10	71.41

Uniform amounts of inoculum composed of mycelium were planted at the center of the Petri dishes. All cultures were kept at room temperature (27-28°C). The mycelial growth was measured and the production of pycnidia was observed daily (fig. 7). The results are summarized in table 2.

Methods of inducing perithecial production. To find the effects of sunlight, low temperature, anaerobic condition, and dryness on perithecial production, the following cultures were made:

1) The fungus mycelium, together with the medium, was cut aseptically into blocks of about 1½ cm. square each. The treated plates were exposed to the sun from 8:00 a.m. to 4:00 p.m., for one week.

2) The plate cultures were kept in a refrigerator for one month.

3) Slant cultures of the fungus were placed in water for one month. Care was taken to keep plugs dry.

4) Four plate cultures were placed in a desiccator for three weeks.

The cultures were examined under the microscope weekly for three weeks. None of the treatments induced production of perithecia.

Germination of pycnospores. Tap water, distilled water, eggplant decoction, nutrient broth, onion agar and potato-dextrose agar were used as media for spore germination. Pycnospores from potato-dextrose agar culture were mounted in each of the first four

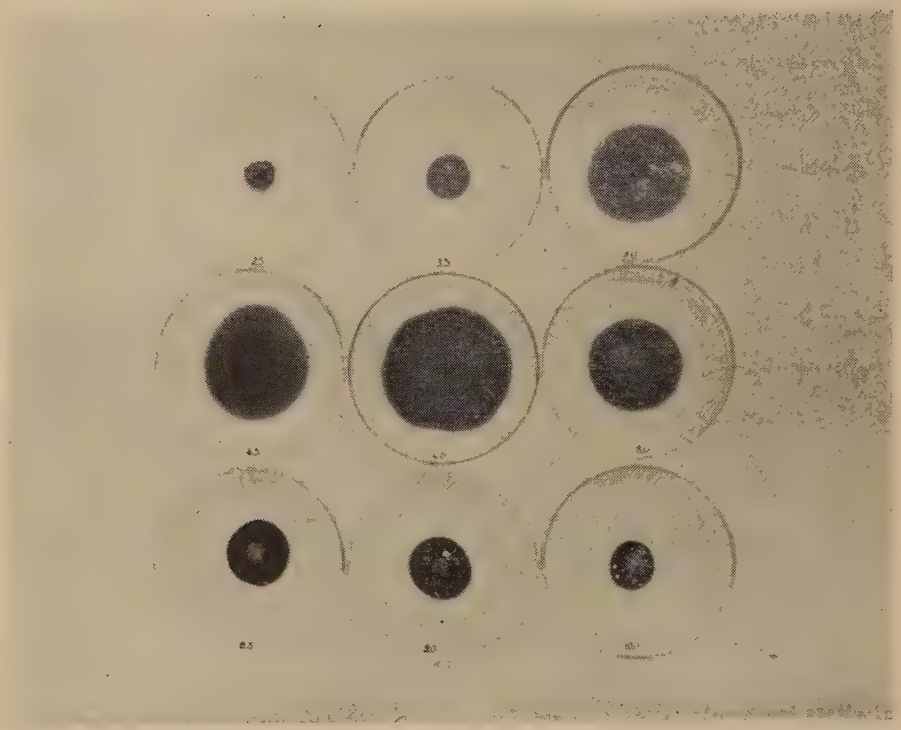

Fig. 7.—Growth and pycnidial production of *Phyllosticta hortorum* Speg. on potato-dextrose agar with pH ranging from 2.5 to 10.0 after 7 days. (*Photograph taken by the Photographic Division.*)

media mentioned in van Tieghem cells, and on thin layers of potato-dextrose agar and onion agar blocks laid on sterilized glass slides. Observations were made hourly for the germination of pycnospores.

Under laboratory room temperature (27-28°C), pycnospores germinated in 6 to 24 hours in nutrient broth, tap water, eggplant decoction, and on potato-dextrose agar and onion agar, and on distilled water in 24 to 48 hours. One germ tube on one end and occasionally two germ tubes, one at each end of the pycnospore, were produced (fig. 5A).

Viability of the fungus. Plate and test tube cultures of the fungus were kept in the laboratory at room temperature (27-28°C). At monthly intervals, viability tests were made. The pycnospores were suspended in tap water in van Tieghem cells and germination was observed. The tests showed that pycnospores from agar medium remained viable for eight months.

TABLE 2.—*Growth and pycnidial production of* Phyllosticta hortorum *Speg. on potato-dextrose agar of different hydrogen-ion concentrations*

PH OF MEDIUM	RELATIVE ABUNDANCE OF MYCELIUM	RELATIVE ABUNDANCE OF PYCNIDIUM	DIAMETER OF COLONY AFTER 6 DAYS [a]	AVERAGE DAILY GROWTH
			mm.	*mm.*
2.5	Very scarce	None	6.47	1.07
3.0	Scarce	Few	21.22	3.53
3.5	Scarce	Few	24.82	4.13
4.0	Abundant	Fairly abundant	53.27	8.88
4.5	Fairly abundant	Abundant	63.18	10.53
5.0	Very abundant	Very abundant	82.15	13.69
5.5	Very abundant	Very abundant	79.29	13.21
6.0	Very abundant	Abundant	72.11	12.01
6.5	Abundant	Abundant	70.44	11.77
7.0	Fairly abundant	Fairly abundant	59.09	9.85
7.5	Fairly abundant	Fairly abundant	53.39	8.73
8.0	Fairly abundant	Fairly abundant	48.17	8.03
8.5	Fairly abundant	Fairly abundant	32.25	5.37
9.0	Scarce	Few	29.91	4.98
9.5	Scarce	Few	27.94	4.65
10.0	Scarce	Few	23.14	3.85

[a] Average of three cultures.

TAXONOMY

The fungus isolated in this experiment and tried on eggplant and tomato in the artificial inoculations could infect these two hosts only when conditions were very favorable for infection and when the hosts were weakened. The fungus studied by the writer closely resembles *Phyllosticta hortorum* Speg., especially in size and shape of the pycnidia and pycnospores (table 3). It differs from *Phomopsis vexans* (Sacc. and Syd.) Harter, the fungus with which it is confused. *Phyllosticta hortorum* Speg. is also called *Phoma solani* Hals., *Ascochyta hortorum* (Speg.) C. O. Smith, and *Phoma vexans* Sacc. and Syd. Harter (1914) found that the last three fungi are identical. For this reason he proposed the name *Phomopsis vexans*. The fungus, *Phomopsis vexans* (Sacc. and Syd.) Harter produces pycnidia with well-defined beaks, and possesses stylospores.

The writer's fungus differs from *Phomopsis vexans* in the absence of stylospores in the pycnidia that are produced on the host or on different artificial media, in the absence of beak, and in pathogenicity to eggplant.

In spite of the little difference in measurements of the pycnidia and pycnospores, which may be due to differences in the media used

TABLE 3.—*Comparative size of pycnidia, pycnospores and presence or absence of stylospores of different fungi referred to as* Phyllosticta hortorum *Speg.*

	MEASUREMENT IN MICRONS			
	Pycnidia	Pycnospores	Stylospores	Name given to fungus
C. Spegazzini (1881)	80-90 in diameter	4-6 × 2-2.5	None	*Phyllosticta hortorum* Speg.
L. L. Harter (1914)	on leaves and stems: 60-200 broad on fruits 120-350 broad	5-8 × 2-2.8	13-28	*Phomopsis vexans* (Sacc. and Syd.) comb.
C. W. Edgerton and C. C. Moreland (1921)	on leaves and fruits: 125-300 width 110-250 height on stems: 700 width 800-950 height in pure culture: 1200 10-30 in thickness	6-8 × 3-4	19-32 × 1-1.8	*Phomopsis vexans* (Sacc. and Syd.) Harter
M. A. Palo (1936)	Pure culture: 76.0-144.0 height 79.8 × 72.0-162.0 Av.: 111.0	Fruit and leaves: 5.0-8.0 × 1.7-3.6	13.3-18.3 length 1.0- 1.7 width Ave.: 15.6 × 1.3	*Phomopsis vexans* (Sacc. and Syd.) Harter
Writer	Pure culture: 53.28-164.84 Av.: 108.38 ± 1.65	4.20-9.45 length 2.31-5.46 width Av.: 5.91 ± 0.065	None	*Phyllosticta hortorum* Speg.

and in the prevailing condition, the writer considers the fungus in this study as identical with *Phyllosticta hortorum* Speg.

PATHOGENICITY

To test the pathogenicity of the fungus, different methods of inoculation were followed: (1) spraying wounded and unwounded vegetative parts and fruits of the plant with spore suspension of the fungus, (2) smearing mycelial fragments of the fungus on the wounded and unwounded vegetative parts and fruits of the plant, and (3) mixing spores and mycelial fragments with the soil. These methods were used in inoculating eggplant at different stages of development.

Experiment 1. On January 18, 1955, eight big eggplants of the Native Long Purple variety were inoculated with the fungus by smearing mycelial fragments on different parts. Four fruits, smeared with sterile potato-dextrose agar, served as control. The inoculated and the control fruits were kept in moist chambers, in three large Petri dishes lined with wet filter paper at the bottom. No infection was observed. The experiment was repeated and negative results were obtained.

Experiment 2. On Febuary 14, 1955, the same number and variety of fruits as in experiment 1 were used in inoculation. No infection was observed at first, but when the inoculated fruits were kept for a week or more in the damp chambers, mild rotting developed on the wounded parts. Subsequent inoculations of young and old fruits showed very slow rotting of the wounded parts and none in other parts.

Experiment 3. On March 3, 1955, twelve 30-day-old plants of Native Long Purple variety were sprayed with spore suspension from a 15-day-old potato-dextrose agar culture of the fungus. The inoculated as well as the check plants were placed in the damp chamber for 72 hours and afterwards placed in the shade for further observation. Lesions were observed on the old lower leaves of the inoculated plants after five days.

Experiment 4. On March 18, 1955, eight plants were inoculated in the same way as in experiment 3. Symptoms on the old lower leaves were observed after five days.

Experiment 5. On May 11, 1955, twenty-one 40-day-old plants were sprayed with spore suspension from 8-day-old potato-dextrose agar cultures. Seven of the plants were pricked with sterilized pin,

seven plants had the trichomes on the surface of the leaves scraped with sterilized scalpel and the rest were not wounded. Ten plants served as control. The same treatments were given to the plants as in experiments 3 and 4. No infection was observed.

Experiment 6. On July 18, 1955, two-week-old seedlings of the varieties [3] Purple, Black Magic, Native White, Florida High Bush, Black Round and Trinidad Long Purple grown in pots of sterile soil were sprayed with spore suspension. Plants of the same varieties, grown in sterile soil and sprayed with sterile distilled water served as control. The same treatment was given to the plants as in previous experiments. No infection was observed.

Experiments 7 and 8. Inoculation experiments were repeated on the same varieties, including Black Beauty on August 21, 1955, in their vegetative stages, and on September 21, 1955, in the flowering and fruiting stages. Different methods of inoculation were followed for every three plants in each inoculation experiment. No symptoms other than shedding of the older lower leaves after two weeks were observed.

Experiment 9. An inoculation experiment with infested soil was undertaken on November 8, 1955, to determine whether or not the fungus is soil-borne. An equal volume of spore and mycelial suspension was mixed with sterilized potted soil. The same number of disinfected seeds of variety Long Native Purple were planted in the artificially infested soil. Five pots of infested soil were used; the same number served as control. The pots were kept in the greenhouse and when the plants were big enough they were transferred outside for further observation. No symptoms of infection were observed.

More trials were conducted, but negative results were obtained, except in few cases when the plants were much weakened.

From these experiments it appears that *Phyllosticta hortorum* is a weak parasite. Infection was produced only when the plants were much weakened and conditions were very favorable for disease development.

Re-isolation of the fungus. In all inoculation experiments only two cases of infection on the leaves were observed. The causal fungus was isolated from the infected leaves. The morphological

[3] These were made available by the Division of Olericulture, Department of Agronomy.

and cultural characteristics of the reisolated fungus were identical with those of the originally isolated fungus.

Varietal susceptibility and resistance. Of the varieties tested, only the Long Native Purple variety showed slight susceptibility. The other varieties, Purple, Black Magic, Native White, Florida High Bush, Black Round, Trinidad Long Purple and Black Beauty could not be infected.

HOST RANGE

Cross-inoculation experiments were conducted to determine whether the fungus will infect other plants besides eggplants. The solanaceous plants used were tomato (*Lycopersicon esculentum* Mill.), talong-punay (*Datura metel* L.), tobacco (*Nicotiana tabacum* L.), potato (*Solanum tuberosum* L.), pepper (*Capsicum annum* L.) and petunia (*Petunia hybrida* Vilm.).[4] Only tomato showed slight infection.

LIFE HISTORY OF THE CAUSAL FUNGUS IN RELATION TO PATHOGENESIS

Seasonal occurrence of the disease. Based on the results of the inoculation experiments the fungus could cause infection during warm moist days. In Los Baños, the weather from the later part of July to early August may be favorable for the development of the fungus.

Source of inoculum. The fungus on the infected tissues produces pycnidia. When the host dies, the fungus persists in this form and also as dormant mycelium. When favorable conditions prevail, the fungus grows and becomes the source of primary infection.

Methods of dissemination. Pycnidia with abundant spores are produced on the surface of the leaves. The pycnospores which ooze out in the form of gelatinous ribbons may be easily spread by water droplets or rain splashes.

Method of infection. Being a very weak parasite, the fungus can develop only when the leaves and fruits are wounded or much weakened.

CONTROL MEASURES

Field sanitation. The fungus may grow saprophytically on decaying plant parts in the field. Infected plant parts should be destroyed or burned to reduce source of inoculum.

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[4] Identified by Mr. Juan V. Pancho of the Department of Agricultural Botany.

Use of fungicides. The following fungicides used for the control of other serious diseases of eggplant are also effective against *Phyllosticta horturum* Speg: Parzate, Dithane Z-78, Manzate at 2 pounds per 100 gallons; COCS at 6 pounds per 100 gallons and Copper A compound at 4 pounds per 100 gallons.

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In many areas our farmers are harassed by destructive plant pests and diseases. We should help them fight the "kadang-kadang" disease in the coconut regions, control mosaic disease of abacá. and eradicate rat infestation. I trust Congress will provide sufficient funds to finance research and control work on these diseases and pests now threatening our major crops.

—*Ramon Magsaysay*

MORPHOLOGY AND CYTOLOGY OF COFFEE [1]

NORMA M. ORLIDO and JOSÉ M. CAPINPIN

WITH FIVE PLATES

Three species of coffee (*Coffea robusta* Linden, *C. excelsa* A. Chev., and *C. liberica* Hiern.), were studied cytologically and observations were made on the trend of flowering and fruit development. A highly significant difference in the percentage of fruit set and peaberry was noted among the species. Liberica had the highest percentage of fruit set and the lowest percentage of peaberry. A negative correlation existed between fruit-setting and peaberry percentages.

The chromosome number of the three species in the somatic tissues was 44. In the microspores 22 chromosomes which appeared to undergo normal meiosis were observed.

The solution to problems associated with coffee growing requires in part a knowledge of its vegetative and reproductive parts. The present investigation aimed to study some morphological and cytological features of coffee which may shed some light on the causes of the failure of some flowers to set, the dropping of some fruits before reaching maturity, and the formation of peaberry.

The experiment was conducted in the College coffee plantation and in the microtechnique laboratory of the Department of Agricultural Botany, from March, 1956 to January, 1957.

MATERIALS AND METHODS

The species used were *Coffea robusta* Linden, *C. excelsa* A. Chev. and *C. liberica* Hiern., all self-incompatible and about to bloom. Ten trees were used for each species, using a single branch from each tree. Flower counts were recorded after petal fall, and fruit set and peaberry percentages were determined at maturity.

Cytological investigations were made on flowers, ovaries, berries, and seeds. Chromosome counts were made on root tip cells and microspores. The materials were collected at different stages of development, fixed in Navashin, and treated according to the paraffin method. Sections were cut at 10 to 12 micra and stained with Haidenhain's iron-alum haematoxylin.

[1] Central Experiment Station Contribution No. 1941. Project No. 841.

Two methods were used in the chromosome studies and counts on the pollen mother cells: the widely used aceto-orcein preparation and Capinpin's smear technique (1930). Cytological illustrations were made by using a camera lucida mounted on a Zeiss microscope, and gross morphological figures were observed and drawn under a dissecting microscope.

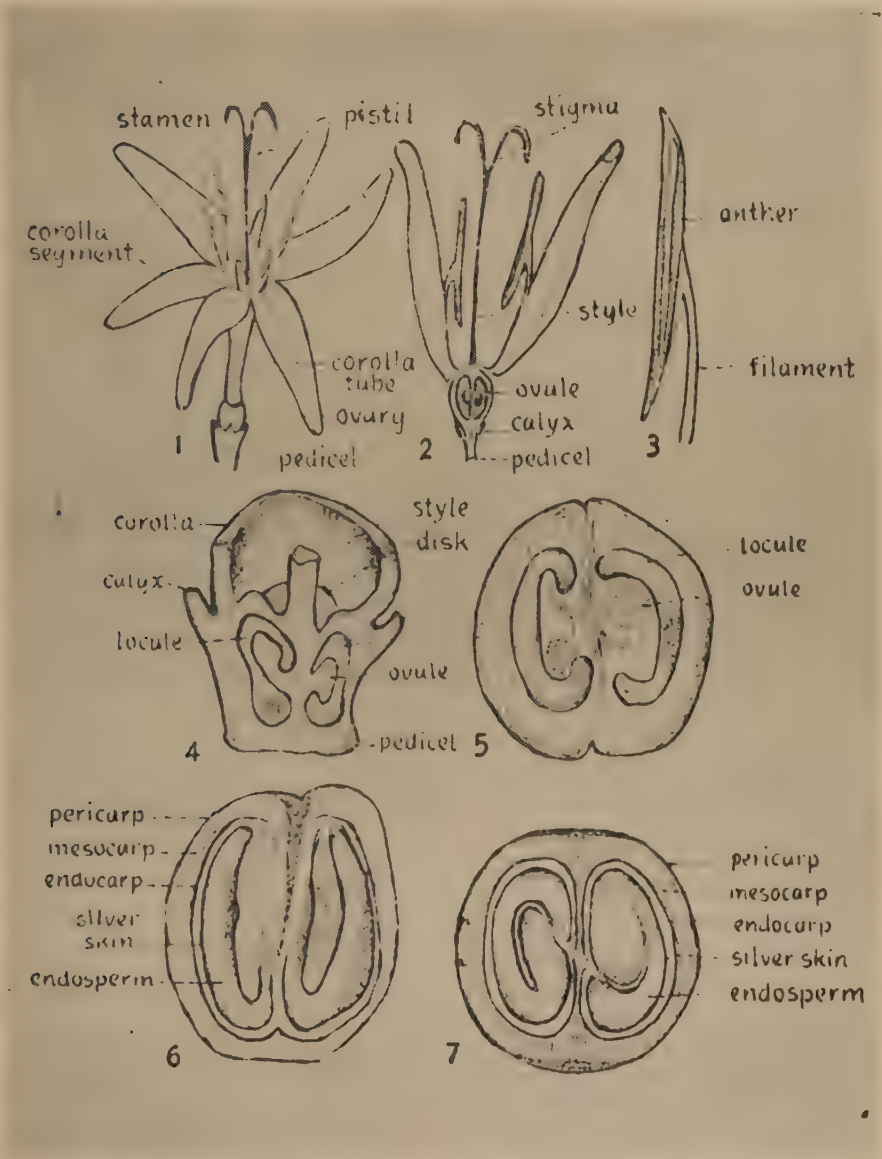
Measurements of floral parts and berries were made on fifty samples from each species and were treated statistically.

RESULTS AND DISCUSSION

Flowers. The flowers are pure white, starlike, tubular, and delightfully scented, and are borne on very short pedicels in one to four axillary clusters of one to five flowers each. The tube of the corolla is divided into five to nine segments (Pl. I, fig. 1).

The style has varying lengths and the stigma is 2-branched. The linear anthers are as many as the corolla segments and are supported by filaments the size of which varies with the condition. The short annular calyx with the denticulate limb is so small as to escape notice (Pl. I, fig. 2). The number and size of the floral parts vary with the species. Liberica flowers are the largest and have the most petals and stamens. They have seven to nine segments. Excelsa has five to seven segments, and robusta has five to six. The coffee flower is perfect and has an epigynous 2-seeded ovary surmounted by a thick ringlike disk. The longi-section and cross section of an open flower are shown in Plate I, figures 4 and 5.

Flowering season. There were two long blossoming periods of one month and several short ones extending from two to three weeks. The three species were found to have different flowering periods. *C. liberica* first blossomed on the first week of February, *C. robusta* on the first week of March, and *C. excelsa* in the middle of March. The second long blossoming period of *C. excelsa* occurred on the first week of May, that of *C. liberica* in the middle of May and that of *C. robusta* in the middle of July. Short blossoming periods also occurred on different dates, and flowers were located on different parts of the branch. Flowers in this period, however, did not set fruit. Flowers were fully open at noon. Flower clusters located on the middle portion of the branch were bigger and opened earlier than those on the terminal and basal parts.



Parts of flower and fruit of coffee.

Fig. 1.—Coffee flower showing parts; (2) Parts of the pistil; (3) Parts of the stamen; (4) Longi-section of the coffee flower; (5) Trans-section of levels indicated in the longi-section; (6) Longi-section of a mature berry; (7) Cross section of a mature berry.

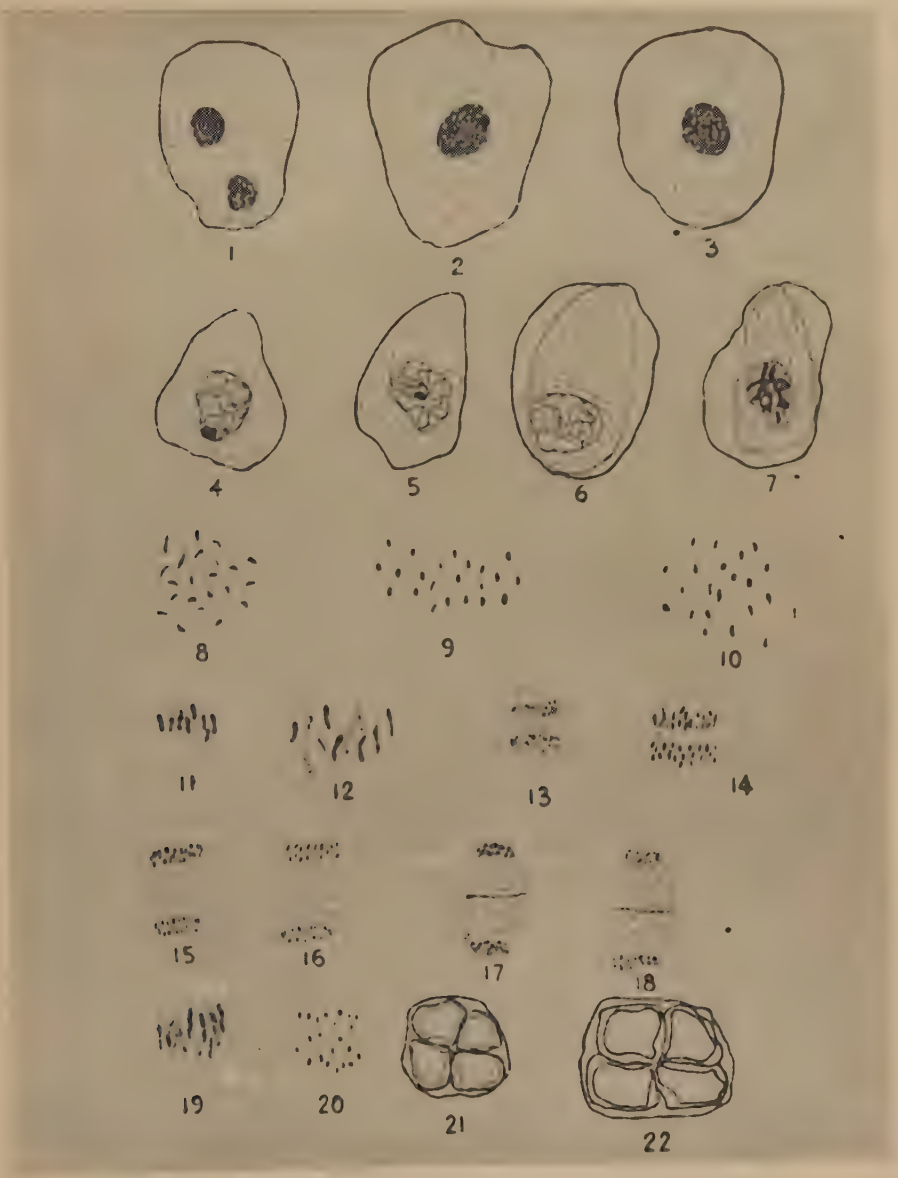
Microsporogenesis and Chromosome at Meiosis

Observations were made on the cellular and nuclear processes in the pollen mother cells of the three species. Chromosome counts indicate that the haploid number of 22 is typical. At resting stage (Pl. II, figs. 1, 2 and 3), a large amount of cytoplasm is visible in the young sporocyte. The nucleus has one nucleolus but some have been observed to have two. At the prophase stage (Pl. II, figs. 4, 5, 6 and 7), the nuclear network is resolved into long slender threads forming the prophase spireme which seems to be continuous. The nucleolus loses its definite shape and place, and occupies the center of the nucleus. Chromatic threads shorten and thicken after the spireme formation. Then follow the shortening and condensing of the nuclear bodies or chromosomes. Different positions are assumed by each chromosome (Pl. II, figs. 8, 9 and 10) at diakinesis stage.

The nuclear membrane then disappears and fibers appear forming the spindle figure of the first metaphase (Pl. II, figs. 11 and 12). Chromosomes assume the shape of forming bivalents. At the later metaphase stage, 22 chromosomes migrate to each pole (Pl. II, figs. 13 and 14). The regularity of meiotic division is shown by the absence of lagging chromosomes at anaphase and telophase stages (Pl. II, figs. 15, 16, 17 and 18). At these stages the double nature of the daughter chromosomes becomes apparent.

There is a well-defined interkinesis between the first and second meiotic mitosis, during which the visible identity of the chromosomes is nearly lost in the reorganization of the daughter nuclei. Cytokinesis begins and the two daughter cells are completely formed before the next division.

The second meiotic mitosis, which immediately follows the first, occurs at about the same time in the two daughter cells. As in the first meiosis, this division of chromosomes is also normal. The achromatic figures are in plane at right angles to each other (Pl. II, fig. 19). It is more difficult to determine the chromosome number in this mitosis than in the preceding one, partly because of the smaller size of the chromosomes and partly because of their more intimate association in the metaphase. However, countings are possible in other stages if materials are favorable. After the stages of meiotic division, the formation of quartets of spores, or the pollen tetrad stage, takes place (Pl. II, figs. 21 and 22).



Gametogenesis and meiosis of coffee pollen mother cells.

Figs. 1–3.—Resting nuclei: (1) robusta, (2) liberica (3) excelsa; 4–7.—Prophase stages: (4–6) liberica, (7) excelsa; 8–10.—Early metaphase: (8) robusta (9) excelsa (10) liberica; 11–12.—Metaphase stages of first division: (11) excelsa, (12) liberica; 13-14.—Anaphase stages of first division: (13) robusta, (14) liberica; 15–16.—Telophase stages of first division: (15) liberica, (16) excelsa; 17–18.—Late telephase: (17) liberica, (18) excelsa; 19.—Metaphase of second division; 20.—Early metaphase of second division of liberica; 21–22.—Pollen tetrad: (21) robusta, (22) liberica; (Figs. 1 to 7.—Smear preparation, × 1250; 8 to 20.—Paraffin method, × 1500; 21–26.—Smear preparation, × 1250 drawn under camera lucida and reduced in reproduction.)

The Chromosomes in Somatic Cells

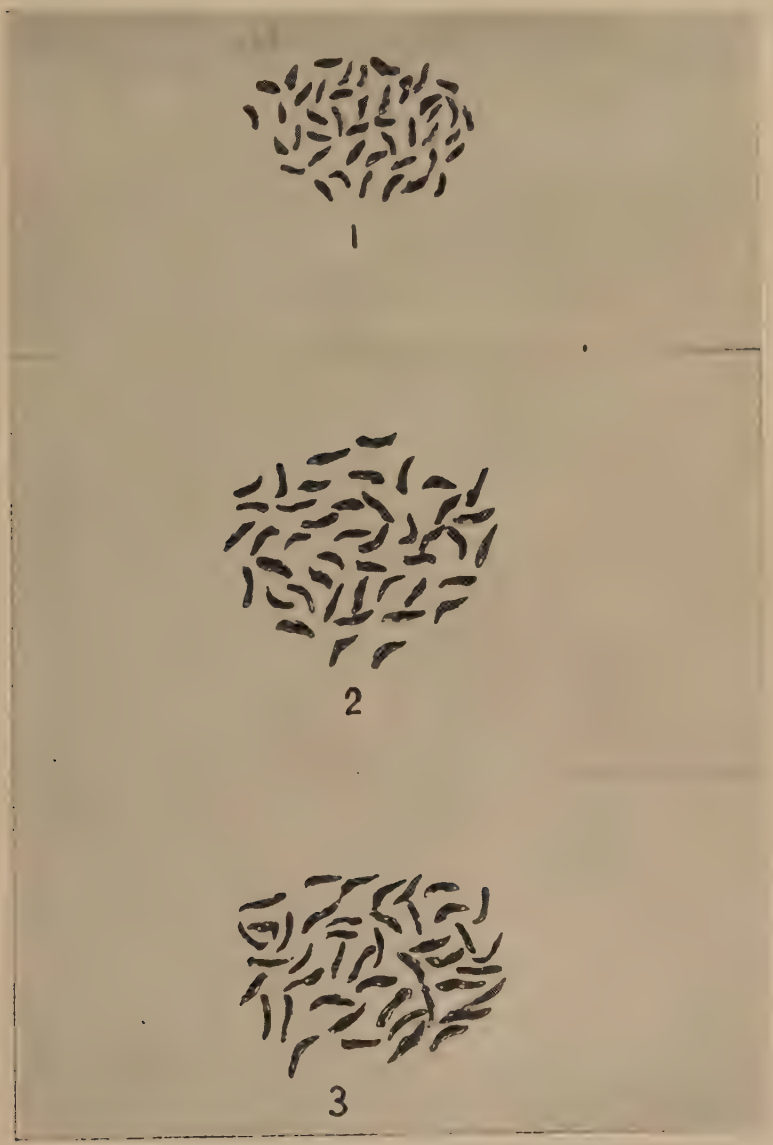
The somatic chromosome number was found to be the same in all the three species studied. Chromosome counts, taken at the somatic metaphase stage, gave a number of $2n = 44$ which is a typical characteristic of all the species (Pl. III). The same plate shows the root tip cells undergoing division.

The chromosome count of 44 in this study appears to be in accordance with the established basic chromosome number of 11 in genus *Coffea,* as gleaned from the works of Krug (1937), Darlington and Janaki (1945) and Medina (1949) and shown in table 1.

TABLE 1.—*Chromosome number in genus coffea (Krug, 1937, and Darlington and Janaki, 1945)*

Coffea N = 11	2N	AUTHOR
C. bengalensis	22	Fagerlind (1937)
C. canephora	22	Doughty (1937)
C. dewevri	22	Krug (1936, 1937)
C. dybouskii	22	Krug (1936, 1937)
C. eugonoides	22	Doughty (1939)
C. excelsa	22	Heyn (1936)
C. semiexserta	22	Homeyer (1932)
C. stenophylla	22	Fagerlind (1937)
C. ugandae	22	Krug (1936)
C. abeokutae	22	Heyn (1936)
	44	Fagerlind (1937)
C. congensis	22	Krug (1934)
	44	Fagerlind (1937)
C. liberica	22	Fagerlind (1937)
	44	Heyn (1936)
C. arabica	22	Homeyer (1937)
V. nacional	44	Krug (1936)
V. bullata	44, 66, 88	Krug (1936, 1937)
C. robusta	22	Krug (1934)
C. excelsa	22	Krug (1934)
C. excelsa	22	Krug (1934)
C. absocutae	22	Krug (1936)
C. arabica	16	Von Faber (1912)
C. arabica var. nacional, bourbon laurina, maragogipe amarella	44	Krug (1934)
C. arabica	44	Folke and Fagerlind (1934)
C. arabica var. angustifolia erecta monosperma, murta polysperma purpurascens and three other new varieties	44	Krug (1936)
C. arabica var. bullata	66	Krug (1936)
C. arabica var. bullata	88	Krug (1936)

[THE PHILIPPINE AGRICULTURIST] [VOL. XLI, NOS. 1 & 2, PLATE III]



Somatic metaphase stages in root tip cells:
(1) robusta, (2) excelsa, (3) liberica.

Berry Development

Fertilization. As a rule embryo sac development is completed before the flower opens (Mendes, 1941). (However, as shown on Pl. IV, fig. 1, an incompletely developed sac was found in an open flower.) Before fertilization the polar nuclei in the embryo sac begin to fuse, and this fusion seems to be accelerated by pollination. The three nuclei give rise to three antipodals and then divide again (Pl. IV, fig. 2).

Following pollination, a pollen tube enters the embryo sac, passing over one of the synergids and settling between the egg and the fused polar nuclei (Pl. IV, fig. 3). The male gametes issue from the pollen tube and unite simultaneously with the female organs, one with the egg and the other with polar fusion nuclei, resulting in a double fertilization. Vacuolation of the cytoplasm of the embryo sac takes place after this double fertilization. The synergids (Pl. IV, fig. 4), which remain untouched by the pollen tube, disappear eight days after flower opening, and the resulting space is occupied by the fertilized egg, which is now increasing in size.

The embryo sac does not enlarge until after the eighth day after flower opening; however, the enlargement becomes perceptible only after the 16th day. At this stage the synergids and antipodals have already disappeared. Sometimes egg cells have also disappeared (Pl. IV, fig. 5), suggesting an incomplete fertilization. Mendes (1941) found that it is under this condition that embryoless seeds are developed.

After the double fertilization the perisperm is formed by the multiplication of cells in the integument. The fruit enlarges and its two seeds acquire their characteristic shape and size. The perisperm, however, is transitory as it will soon be displaced by the endosperm.

Endosperm. The primary endosperm nucleus undergoes no division within 20 days after pollination (Pl. IV, fig. 6), thus confirming Houk's (1938) report that the endosperm nucleus passes a long rest period after pollination. In this work, however, no division was observed until after the 28th day when the endosperm was already at its tetranucleate stage (Pl. IV, fig. 7). The first division or binucleate stage must have taken place between the 21st and 27th days after flower opening. This deduction seems to agree with the finding of Mendes (1941) on *C. arabica.*

The octa-nucleate stage is reached on the 42nd day (Pl. IV, fig. 8) and the multinucleate stage on the 64th day. As the endosperm increases in size it presses the tissue surrounding the embryo sac and on the 72nd days assumes an ovoid shape. When the ovaries are about four months old, the endosperm, except for a thin layer, completely replaces the perisperm (Pl. IV, figs. 9 and 10).

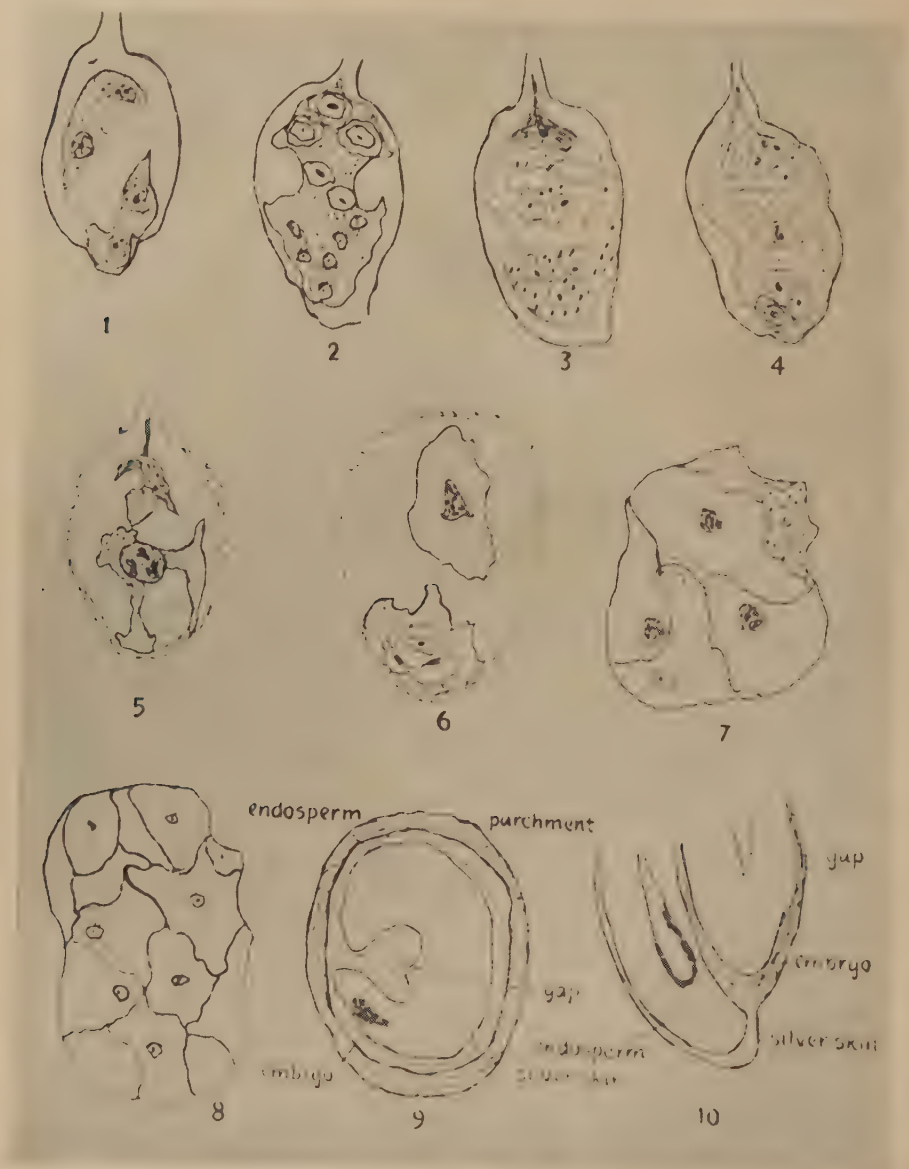
Embryo development. The fertilized egg remains at a resting stage during the endosperm development, and not until the endosperm has reached its multinucleate stage does the first division in the egg take place to form the first two daughter cells, the basal and the apical. A transverse wall immediately forms between the two cells. The basal cell is located near the micropyle and is larger than its sister cell.

The succeeding phases of the development of the embryo were not examined in detail because of the rapidity of the division and the consequent increasing difficulty in handling the material. But as observed by Mendes (1941), the apical cell divides transversally again. As a result of this second division a 3-celled proembryo is formed, the median cell of which is somewhat compressed between the other two.

When the berries are about three and a half months old the embryo is already shield-shaped (Pl. IV, fig. 9). (At this stage the endosperm has completely replaced the perisperm, of which only a silver skin now remains.) A space around the embryo appears and increases in size, forming a break through the endosperm and separating it into halves (Pl. I, fig. 6). The seed having an embryo, endosperm, and silver skin is completely formed. The ripening process goes on without further morphological changes.

Fruit-setting. A large percentage of flowers is shed off as ovaries and immature berries. Based on 10 observations, only 46.6 per cent of *C. liberica* flowers, 43.8 of those of *C. excelsa,* and 38.7 of those of *C. robusta* developed into mature berries (table 2). Such low fruit set was attributed to adverse weather during flowering and to some physiological defects in the berry development similar to results found by Frahm-Leliveld (1938).

Fruit-dropping. Two distinct waves of fruit-dropping were observed. The first wave began after petal fall and lasted until the fifth month of the developmental period. A dropped fruit is yellow-



Cytological observations in Coffee.

Fig. 1.—Embryo sac from an open flower having four nuclei; 2.—Formation of supernumerary antipodals in an embryo sac not yet fertilized; 3.—Pollen tube entering a complete embryo sac; 4.—Disappearance of the synergids in a fertilized embryo sac; 5.—Disappearance of egg cell in a fertilized embryo sac; 6.—embryo sac 20 days after flower opening; 7.—Endosperm having 4 nuclei after 28 days of opening; 8—Octanucleate stage of a 42-day-old ovary; 9.—Transverse section of fruit 72 days after flower opening. Embryo already shield-shape; 10.—Longi-section of a 72-day-old ovary; (Figs. 1 to 8.—Camera lucida drawings, × 900; 9 to 10.—Free-hand drawing, × 12).

ish green, and is smaller than a developing one which is a shade darker. It contains water-soaked tissue, which shows that the ovary has not been fertilized.

The second wave of fruit-dropping began in the fifth month and continued until maturity. Only a few dropped during this period. Dropped fruits are excess fertilized ovaries and, except for their smaller size, have no apparent structural difference from mature ones. Endosperms of dropped fruit, however, are soft and yellowish brown, not as hard and greenish as mature ones. The embryos, too, are normal but have ceased to develop further.

Defective berries. Faulty seed formation is of two kinds. The first consists of abortion at an early stage of one of the two beans which later becomes a horny pellicle. As a result its partner has the entire ovarian cavity at its disposal and a round eggshaped bean known as "peaberry" develops.

The second defect is called "empty bean" and may affect both beans. After normal development the endosperm ceases to grow, as shown by notched edge, and a bean which is much lighter than a regular one is formed. In general, empty beans have a normal embryo.

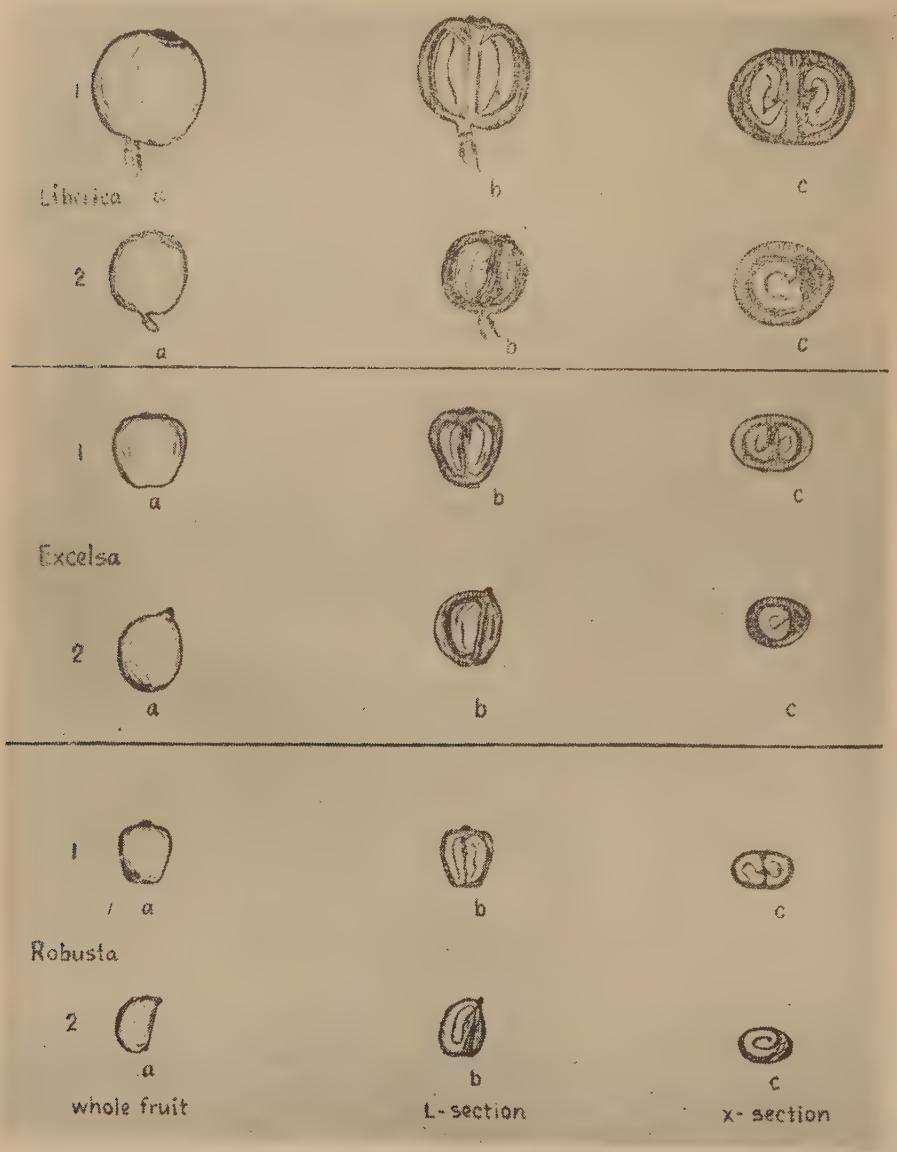
However, no empty bean was discovered in any of the species studied. This suggests that this defect is common only to interspecific hybrids and self-compatible species.

In this work, it was found that peaberry is common to the three species. Its percentages, however, varied with the species (table 2).

Robusta had the highest percentage, and *liberica,* the lowest. The difference may have been due to overcrowding of berries in the clusters and competition for food supply on *robusta,* and the relatively fewer berries on *liberica.* The peaberry percentage on *robusta* was significantly higher than on *liberica.*

A peaberry can easily be detected in any species. It is somewhat irregular in shape, smaller than a normal two-seeded berry, and bends slightly to one side (Pl. V). A pronounced negative correlation was found between fruit-set and peaberry percentages. A low fruit-setting was always accompanied by a high percentage of peaberry (table 2).

Three-seeded berries were also found common to the three species.



Relative sizes and forms of 3 species of Coffee under study.

Liberica 1.—Two-seeded berry: (a) whole berry, (b) longi-section (c) cross-section; 2.—Peaberry: (a) whole berry, (b) longi-section, (c) cross-section;

Excelsa 1.—Two-seeded berry: (a) whole berry. (b) longi-section, (c) cross-section; 2.—Peaberry: (a) whole berry, (b) longi-section, (c) cross-section: (11) excelsa, (12) liberica; 13-14.—Anaphase stages of first section;

Robusta 1.—Two-seeded berry: (a) whole berry, (b) longi-section, (c) cross-section; 2.—Peaberry: (a) whole berry, (b) longi-section, (c) cross-section. (Free hand drawing 1×, reduced to ⅓× in reproduction.)

TABLE 2.—*Percentage of fruit set and peaberry of the three species*

TREE NUMBER	ROBUSTA		EXCELSA		LIBERICA	
	Fruit set	Peaberry	Fruit set	Peaberry	Fruit set	Peaberry
1	41.7	23.4	51.3	23.1	51.9	12.9
2	36.8	27.4	49.9	22.7	47.0	12.8
3	33.9	30.7	46.3	25.7	42.6	15.6
4	44.8	21.2	54.4	21.6	42.2	16.4
5	46.7	20.8	43.0	25.2	43.9	12.9
6	31.4	29.1	38.4	25.3	48.9	11.4
7	35.0	26.9	41.3	26.4	46.4	12.5
8	41.1	25.2	44.2	25.7	50.7	11.8
9	28.7	37.3	34.2	26.7	45.3	11.1
10	47.9	20.5	35.4	27.4	47.7	13.7
Total	387.1	262.5	438.4	242.8	466.6	131.1
Mean	38.71	26.25	43.84	24.18	46.66	13.11
Transformed angle	38.2	30.73	41.43	29.97	43.08	21.19

Fruit set:
SMD transformed angle at 5% = 3.04
at 1% = 4.11
Peaberry:
SMD transformed angle at 5% = 2.06
at 1% = 2.78

Fruit. The fruits are borne in clusters at the leaf axil along the spreading branches. The relative sizes of berries, including their longi-sections and cross-sections, are shown in Plate V. A *robusta* berry is smaller than that of *excelsa* and *liberica.* When ripe it is dark red, ovoid and fleshy and has thin rind. An *excelsa* berry is short, broad, crimson, and smaller than that of *liberica.* A *liberica* berry is large, round and dull red, and has a thick, juiceless, slightly bitter pulp.

The length, width, and circumference of normal berries and peaberries of the three species are shown in table 3. Marked differences in size can be noted.

TABLE 3.—*Relative sizes of berries of the three species (averages of 50 samples)*

SPECIES	LENGTH	WIDTH	CIRCUMFERENCE
	cm.	*cm.*	*cm.*
Robusta			
two-seeded	1.62	1.74	4.37
peaberry	1.26	.92	3.11
Excelsa			
two-seeded	1.79	1.86	5.03
peaberry	1.47	1.23	3.96
Liberica			
two-seeded	2.46	2.38	6.88
peaberry	2.07	1.82	5.33

SUMMARY

C. liberica has larger flowers and berries and more petals, stamens, and segments, and blossoms earlier than *C. robusta* and *C. excelsa*.

Double fertilization occurs a day after the flower opens. The embryo sac then increases in volume and presses the inner integument cells. The outer integument cells multiply to form the perisperm.

After degeneration of synergids and antipodals, the zygote enters into a resting stage near the micropyle until the endosperm has reached the multinucleate stage.

The first division of endosperm occurs within 21 to 27 days after flower opening. As the endosperm enlarges the perisperm is pressed to give room to the new tissue.

The fertilized egg begins to divide 60 to 70 days after flower opening and completes development about one and a half months later.

A pronounced negative correlation exists between fruit-set and peaberry percentages. *C. liberica* had the greatest percentage of fruit set and the lowest percentage of peaberry.

Weather conditions during flowering adversely affected the setting of fruit, and climatic factors governing the physiological processes in the coffee plant were one cause of the failure of some fertilized ovaries to develop into mature fruit.

Shedding of immature fruits, a natural process to prevent overloading, occurred in two separate periods. During the first period unfertilized or incompletely fertilized ovaries were shed; during the second, half-developed berries were discarded.

Three-seeded berries were found in all species but there was not a single empty bean.

The three species have the same chromosome number in root-tip cells and microsporocytes. Gametic cells have 22 chromosomes and somatic cells have 44.

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* * *

Agriculture is the world's first industry and men of the soil are men of peace. Farmers feed the world and without them our giant industrialized countries could not exist. It is fitting that their voice should be heard in international affairs. I need not tell you how important it is to reduce the uncertainties and economic waste arising from excessive fluctuations in the prices of primary commodities.

—*Dag Hammarskjold*

STORAGE OF EAR CORN IN CRIBS [1]

A. B. Catambay, A. C. Hernit, and H. E. Gray [2]

WITH THREE TEXT FIGURES

Husked ear corn with 17 per cent moisture stored in bamboo cribs 2½ feet thick and exposed to natural air movement for aeration did not show spoilage. Intermittent aeration with the fan operating only when the relative humidity was lower than 85 per cent showed better results than either the continuous or natural aeration.

Heavy damage to the stored grain was caused by weevil. Damage caused by rats was easily remedied.

The storage of corn on the farm gives rise to many problems in the corn growing areas of the Philippines. Not only must the storage structure provide proper storage conditions to keep the corn in good quality, but it must also be within economical reach to the farmer. In the United States and other major corn growing regions, the storage of ear corn in open cribs is common practice. However, unlike the Philippines, these countries have weather conditions at harvest time favorable to the success of this type of storage.

To study the feasibility of open crib storage of ear corn under Philippine conditions, an experiment was conducted by the Department of Agricultural Engineering at the Central Experiment Station from September 29, 1956 to January 19, 1957.

MATERIALS AND METHODS

The three methods of aeration employed in this experiment were: (1) natural air movement through the ear corn in the crib, (2) continuous forced air through the ear corn, and (3) forced air through the ear corn when the relative humidity was 85 per cent or below.

Fan Calibration

The two eleactric motor-driven fans used in the experiment had the following specifications:

motor: h.p.—1/6
r.p.m.—1750

[1] Central Experiment Station Contribution No. 1942. Project No. 878. This study was made possible by a NARIC grant.

[2] The authors acknowledge the help of Mr. Abelardo B. Cachuela of the Department of Agricultural Engineering in conducting the experiments.

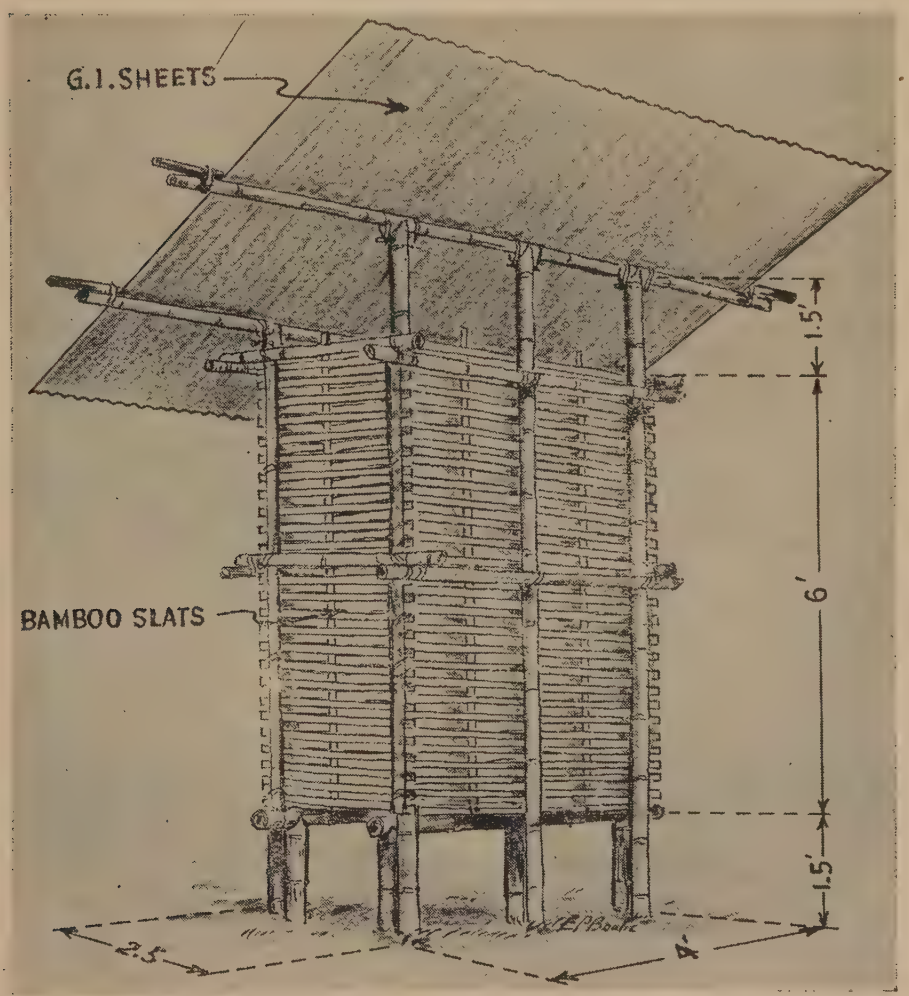
fan: number of blades—4
diameter—9½
capacity, c.f.m.—680 (determined through laboratory calibration)

Air was forced through the ear corn in the artificially aerated cribs at the rate of 40 c.f.m. (cubic feet per minute) per cavan ear corn.

Crib Design and Construction

The cribs selected were 4 feet long, 2½ feet wide and 6 feet deep, with a capacity of slightly over 20 one-cavan sacks of ear corn when full. The floors of the cribs were 18 inches above ground level.

The plan of construction is shown schematically in figure 1.



Large bamboo corner poles set in the ground furnished the main structural support for the cribs. Walls and floors were made of split bamboo ("sala") interwoven with open space between the strips to permit free air movement. The sloping roof made of galvanized steel roofing sheets was given wide overhang to shed off the rain.

Special features were added to the two other cribs which were to be aerated with fans (fig. 2). The space around the bottom under the floor was enclosed with plywood to form a plenum chamber which would direct the air up through the floor thence through the ear corn in the crib. The walls were lined on the inside with heavy paper so that air would be forced to pass all the way up through the corn without leaking out of the sides.

A short duct of plywood was used to connect the fans to the plenum. Installed in the duct of the continuously operating fan were two thermometers, one with a wet bulb. These were placed on the discharge side of the fan, and readings of dry-bulb and wet-bulb thermometers were taken. Fourteen 1-cavan sacks of ear corn were placed in each crib on September 28, 1956. The kernel moisture content ranged from 17 to 19 per cent.

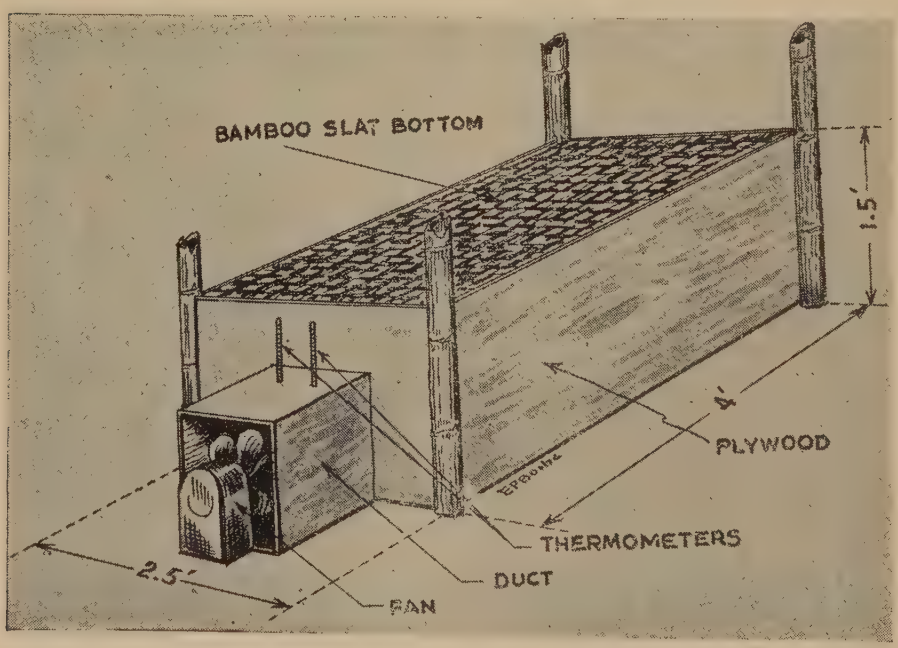


Fig. 2.—Plenum Construction and Fan Mounting
Scale: 1" : 1"

Immediately after filling, the fan in the lot with continuous aeration was switched on. Daily temperature readings were taken of the wet- and dry-bulb thermometers at 8 a.m., 11 a.m., 2 p.m., and 4 p.m. (Sundays excluded) and converted into relative humidities.

The operation of the fan for the intermittent aeration was scheduled on the basis of the relative humidity determinations. Whenever one of the daily readings showed a relative humidity of 85 per cent or below, the fan was operated; at readings above this level, the fan was shut off. Everyday at 4 p.m. the fan was shut off regardless of the relative humidity readings, and operation was not started until 8 a.m. the following day.

The four daily relative humidity readings were used to compute the average daily daytime relative humidities. The dry-bulb readings were used to compute the average daily daytime temperatures. Average daily temperatures (including night time) were taken from the records of the College of Agriculture Weather Station. No records of night time relative humidities were available.

A heavy rain on December 11 wet both fan motors so that on December 13 they became inoperative. At this time, the fans and plenum chambers were removed from the aerated cribs. The paper linings were also removed to permit natural air movement through the corn. The experiment was continued until January 19 to determine the effect of exposure of the artificially aerated corn to natural atmospheric conditions.

Moisture contents of both kernel and cob were determined weekly. Five ears were taken at random from each crib for dry oven moisture determination. These same ears were inspected for molds or other possible moisture damage. At the same time, five temperature readings were taken in each crib with a dial thermometer to determine whether there was evidence of heating.

Weekly readings were also taken of static pressures developed in the aerated cribs to determine the air flow rate and the resistance to air flow of the corn. Before installation, the two fans were first calibrated and the curves prepared to show the relation between air flow and discharge. Throughout the period of aeration, each fan delivered air at the rate of approximately 40 c.f.m. per cavan.

RESULTS AND DISCUSSION

Moisture content of the corn. The weekly readings of kernel moisture content which are shown in table 1 are plotted in figure 3. Included also is a plot of the weekly summary of daily relative humidities. Each point on this plot represents the summary of the daily humidities for the period immediately preceding the day dur-

TABLE 1.—*Summary of moisture content of corn*

DATE	AVERAGE DAILY RELATIVE HUMIDITY (Preceding Period)	KERNEL MOISTURE CONTENT (Wet Basis)			COB MOISTURE CONTENT (Wet Basis)		
		Intermittent Aeration with Fan	Continuous Aeration with Fan	Natural Air Movement	Intermittent Aeration with Fan	Continuous Aeration with Fan	Natural Air Movement
September 29 [a]	—	17.0	17.8	19.0	19.0	19.0	18.0
October 6	81.2	16.5	17.5	17.0	15.0	22.0	23.0
October 13	84.8	17.5	17.8	18.7	18.0	18.5	17.0
October 20	76.3	15.8	16.7	15.8	14.0	13.5	13.5
October 27	71.9	15.6	16.7	16.4	13.5	13.0	13.0
November 3	69.2	15.2	16.1	15.8	13.5	14.0	12.0
November 10	71.4	15.0	16.9	15.5	9.5	12.0	12.0
November 17	84.6	15.3	17.0	16.3	12.0	13.5	13.0
November 24	76.8	15.3	15.9	14.8	11.0	13.5	12.5
December 1	74.3	15.3	17.3	17.0	12.5	14.5	13.0
December 10	84.8	15.3	17.4	17.3	13.0	11.5	12.5
December 15 [b]	81.2	15.6	17.5	17.5	13.0	14.5	9.0
December 24	79.1 [c]	16.2	16.2	16.3	14.0	14.5	14.0
December 29	78.2	15.6	15.1	15.9	10.5	12.0	13.0
January 5	84.6	15.4	14.8	15.6	11.0	12.0	13.0
January 12	81.9	15.4	14.9	15.8	12.2	12.0	12.8
January 19	74.3	15.4	14.8	14.6	13.0	13.0	10.5

[a] Day following loading.
[b] Fan operation discontinued on December 14.
[c] Records subsequent to discontinuance of fan taken from College Weather Station.

ing which corn moisture content was taken. Additional weather data and corn temperature are summarized in table 2.

Following the trends of moisture content in figure 3 during the period of aeration, it appears evident that the intermittent fan operation lowered the kernel moisture content more rapidly and maintained it at lower level than either continuous aeration or natural air movement. Continuous fan operation resulted in the highest moisture content. With intermittent aeration, the fan was

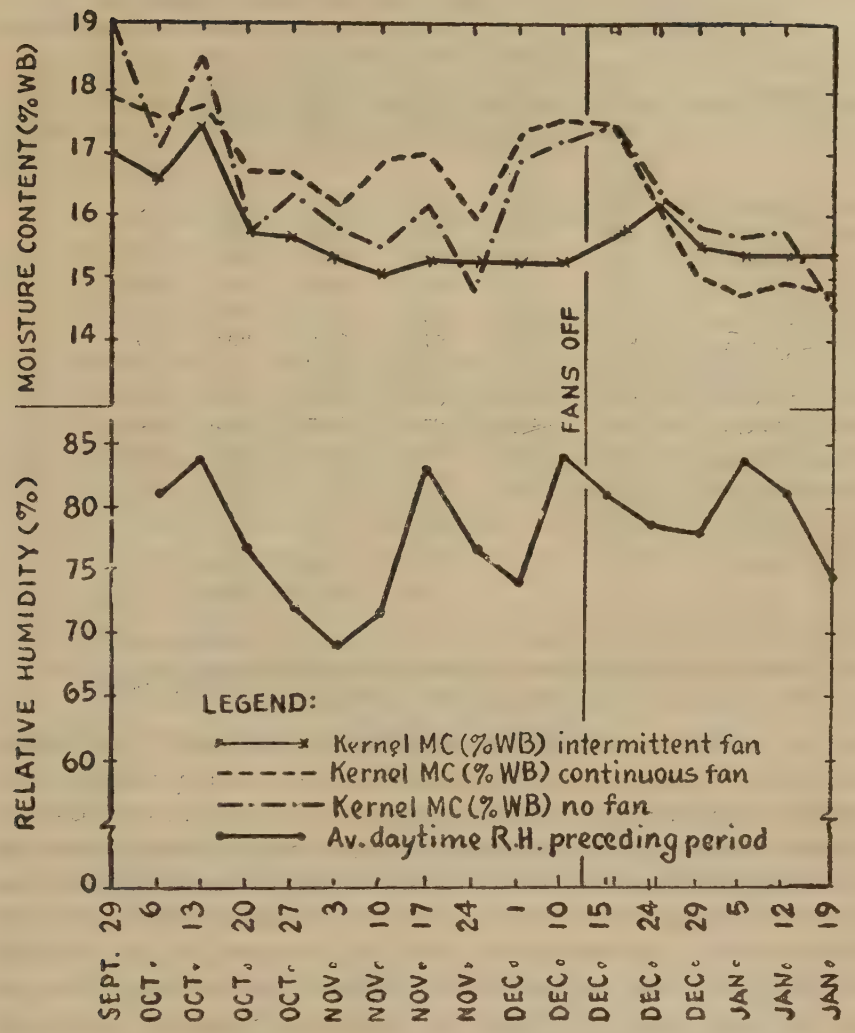


Fig. 3.—Kernel Moisture Content

operated only during periods when the relative humidity was below 85 per cent. During night time and other periods when the relative humidity was higher than 85 per cent, the fan was shut off. The corn subjected to intermittent aeration showed the lowest moisture content.

The moisture content of the continuously aerated corn and that exposed to natural air showed a tendency to follow the trend of the relative humidity of the air. The high moisture content in the con-

TABLE 2.—*Summary of weather data and corn temperature*

PERIOD Dates Inclusive	MEAN DAILY TEMPERATURE	(24 Hrs.) AVERAGE DAILY TEMPERATURE (Daytime)	CORN TEMPERATURE IN CRIBS			TOTAL TIME OF INTERMITTENT FAN OPERATION	NO. OF RAINY DAYS DURING PERIOD [b]
			Intermittent Aeration with Fan	Continuous Aeration with Fan	Natural Air Movement		
	°F	°F	°F	°F		*Hours*	
Sept. 29–Oct. 5	78.7	80.8	84.9	82.6	84.8	43	5
Oct. 6–Oct. 12	80.4	81.5	83.2	81.4	84.2	27	4
Oct. 13–Oct. 19	80.4	83.5	86.6	84.6	86.5	37¾	2
Oct. 20–Oct. 26	82.6	85.0	88.8	88.0	91.1	48	1
Oct. 27–Nov. 2	81.8	85.7	91.2	91.6	91.8	40	1
Nov. 3–Nov. 9	81.4	84.9	91.5	88.0	90.9	45	2
Nov. 10–Nov. 16	79.2	79.2	90.8	89.6	91.1	19	5
Nov. 17–Nov. 23	81.9	83.4	86.5	82.1	86.0	38½	2
Nov. 24–Nov. 30	78.3	80.6	87.0	84.7	87.5	35¼	1
Dec. 1–Dec. 9	77.2	78.6	75.6	72.6	76.4	29½	6
Dec. 10–Dec. 14	78.1	79.6	82.6	75.9	84.2	18	3
Dec. 15–Dec. 23	78.4	[a]	79.0	73.1	79.3	[a]	4
Dec. 24–Dec. 28	77.9		76.4	72.0	78.0		1
Dec. 29–Jan. 4	78.0		76.8	76.8	77.4		4
Jan. 5–Jan. 11	75.9		82.6	75.1	82.4		1
Jan. 12–Jan. 18	77.0		78.2	73.8	77.2		0

[a] Records discontinued when fan operation was stopped.
[b] Days in which 0.10 or more inches of rain fell in 24-hour periods.

tinuously aerated crib might be explained on the basis of air movement. Both these cribs were exposed to night and day weather conditions. However, the air movement caused by the fan was positive, whereas the natural air movement is dependent to a large extent on the wind. Although no records are available, generally it is a natural phenomenon that wind movement at night is less than that during the day. Assuming this to be true, the corn in the naturally ventilated crib was exposed to a relatively smaller proportion of high moisture night air than the continuously aerated corn with directed movement. The fan pumped moisture-laden night air through the crib.

As soon as the fan operation was discontinued, the moisture content of the corn in the three cribs tended to equalize so that at the end of the experiment, very little difference among them was apparent.

Although the cob moisture contents were recorded, they are not shown here since the trends were very similar to those of the kernel moisture content.

On November 28 and December 10, 1956, all three cribs were wet from the heavy rains that fell during the periods.

After 77 days of crib storage (September 29th to December 15th) the average kernel moisture contents were: intermittent aeration, 15.6 per cent; continuous aeration, 17.5 per cent; and, natural aeration, 17.5 per cent.

During the entire period of the experiment, there was no evidence of mold or other moisture damage to the corn in any of the three cribs.

Temperature of the corn. High temperature of corn is evidence that damage occurs due to "heating." The temperature summaries show that the corn temperature in the crib with continuous aeration was maintained at a lower level than either of the corn exposed to intermittent or natural aeration. There was very little difference between temperatures of the corn in the intermittently aerated and naturally ventilated cribs. The positive movement of the cooler night air in the continuously aerated crib tended to hold the temperature of the grain at a lower level.

Other observations. The 40 c.f.m. per cavan of air flow used in this experiment is higher than that which should be used. However, the fans were permitted to operate at their normal capacity with no attempt to restrict air flow other than the resistance of the corn itself.

Weevil damage to the corn in the cribs during the experiment was serious and posed a problem which must be resolved before this method of storage can be deemed feasible. Damage caused by rats was easily remedied.

* * *

In reality the scientific method, of which so much is spoken for both good and ill, is whatever means may be appropriate for solving problems in the natural environment. The working scientist brings to bear upon these problems everything at his command—previous knowledge, intuition, trial and error, imagination, formal logic, and mathematics—and these may appear in almost any order in the course of working through a problem.

—*N. E. Stevens*

THE PHOSPHORUS REQUIREMENT OF POULTS[1]

G. O. Ranit

The availability of phosphorus from various inorganic materials for the turkey poult was determined by using reagent grade dicalcium phosphate, commercial grade dicalcium phosphate, defluorinated rock phosphate, steamed bone meal, Curacao Island phosphate, and colloidal phosphate. The percentages of bone ash show that the phosphorus from the commercial dicalcium phosphate and from the defluorinated rock phosphate was better utilized than that from the reagent grade dibasic calcium phosphate, steamed bone meal, Curacao Island phosphate or colloidal phosphate.

The addition of the ash of four unidentified factor supplements (UFS) to the commercial dicalcium phosphate, effected no improvement in the tibial ash contents of turkey poults as compared to the ash contents of the poults which received the same levels of phosphorus from the commercial dicalcium phosphate alone. However, the addition of ash from the four UFS to reagent grade dibasic calcium phosphate caused a marked improvement in calcification as compared to the same levels of phosphorus from the reagent grade phosphate alone. These results seem to indicate that the improved calcification from the reagent grade dicalcium phosphate plus ash treatments were due to the superior utilization of the phosphorus in the ash as compared to the phosphorus in the reagent grade dicalcium phosphate.

Phosphorus is a critical element in poultry rations. It is necessary for poults, as well as for all animals, for body growth, development of bones, and maintenance of vital body functions such as acid-base balance, muscle metabolism, enzyme systems and metabolism of carbohydrates, fats, and proteins. When animals do not receive optimum amounts of phosphorus in the diet, growth is not only retarded but a disease known as rickets also develops in varying degrees of severity depending upon the extent of the phosphorus deficiency. Chicks and poults affected with rickets become very weak, and, if the phosphorus deficiency is severe, they eventually die. To prevent phosphorus deficiency, therefore, the diet must contain adequate amounts of a supplement in which the phosphorus is present in a form available to the chicks or poults.

At present feed manufacturers use different kinds of inorganic phosphate materials as sources of phosphorus in formulating livestock and poultry rations. Since the nutritional value of different kinds of phosphate materials as reported in most studies with chicks

[1] Miscellaneous Contribution No. 35.

differ due probably to differences in availability for chicks of the phosphorus in these supplements, it would be of interest to determine whether or not the availability for the poults of the phosphorus in these supplements also varies and to what extent it varies. With this objective, these studies were conducted in the Department of Poultry Husbandry at Cornell University from May 15, 1956 to July 17, 1956 inclusive.

EXPERIMENTAL PROCEDURES

Experiments 1 & 2. A total of 190 Empire White day-old poults of mixed sex were used in these experiments. Experiment 1 consisted of 10 lots with 12 poults to a lot. In experiment 2 there were only 7 lots with 10 poults to each lot. The poults were randomly distributed among the different lots.

The wingbanded poults were housed in electrically heated wire-floored battery brooders adequately provided with feeding pans and drinking bottles. The temperature for each brooding pen was automatically regulated.

The initial and weekly individual weights of the birds were taken until they were three weeks of age. During the second and third weighings, observations on the incidence of rickets were made. Either the right or left tibiotarsus was examined for degree of severity, if any, of the ricket condition and scores were assigned with increasing rickets as 1, 2, 3, 4 and 5.

The composition of the basal diet used in this study is shown in table 1.

TABLE 1.—*Composition of basal diet*

INGREDIENT	PER CENT
Soybean meal (50% protein)	69.7
Corn Starch	13.2365
Mineral Mix	3.9584
Vitamin Mix	0.5
D-L Methionine	0.65
Glycine	0.5
Hydora (vitamin E-free lard)	7.0
Choline Chloride (70% solution)	0.2475
Vitamin A (Nopcay 10)	6000 IU/lb.
Vitamin D (Delsterol)	1000 IU/lb.
Vitamin K (Menadione)	9 mg/lb.
Vitamin B_{12}	4.4 mcg/100 grams
Biotin	22 mcg/100 grams
Vitamin E (alpha tocopheryl acetate)	30 mg/lb.
DPPD	100 mg/lb.

This diet contains approximately 36 per cent protein. By actual analysis it was found to contain about 0.55 per cent phosphorus. Since the phosphorus content of the basal diet is of plant origin, it is presumed that its availability to the turkey poult is low since this was so in previous studies using the chick. The poults, therefore, would be more dependent for their major phosphorus requirements on the inorganic phosphorus supplements than on the organic phosphorus contained in the basal diet. The composition of the mineral mixture used in these studies is shown in table 2 and the vitamin mixture in table 3.

TABLE 2.—*Composition of mineral mixture*

COMPOUND	PER CENT
$CaCO_3$	2.0
KCl	0.7
NaCl	0.9
$MnSO_4.H_2O$	0.05
KI	0.006
$FeSO_4.7H_2O$	0.055
$CuSO_4.5H_2O$	0.002
$ZnCl_2$	0.001
$CoCl_2.6H_2O$	0.0004
$MgSO_4$	0.244

TABLE 3.—*Composition of vitamin mixture*

VITAMIN OR INGREDIENT	PER CENT
Niacin	0.0088
Calcium patothenate	0.0022
Riboflavin	0.001
Thiamine hydrochloride	0.001
Pyridoxine	0.001
Folic acid	0.00022
Corn starch	0.48578

To the basal diet which was deficient in inorganic phosphorus phosphate materials from various sources were added. In the first experiment, the graded levels of phosphorus added in each lot for reagent grade dicalcium phosphate were 0.23, 0.46, 0.69 and 0.92 per cent, respectively. For the commercial grade inorganic phosphates (Curacao Island, colloidal, steamed bone meal, defluorinated, and dicalcium phosphate), only the 0.46 per cent level of phosphorus supplementation was used in each lot. In the second experiment,

two levels, 0.46 and 0.69 per cent, were used for reagent grade and commercial grade dicalcium phosphate and only the 0.46 per cent of added phosphorus for Curacao Island phosphate in three lots.

The calcium content for all the diets was computed to be 2.1 per cent. Since the phosphorus content of the basal diet was 0.55 per cent, the calcium:phosphorus ratio for the 0.23 per cent phosphorus level was 2.69:1; the 0.46 per cent level, 2.1:1; the 0.69 per cent level, 1.69:1; and the 0.92 per cent phosphorus level, 1.43:1. Where the supplementation did not supply the right calcium:phosphorus ratio because of variation in the amounts of calcium and phosphorus in the various phosphate materials used, the ratio was adjusted by adding calcium carbonate. To make the formula 100 per cent after the phosphorus and calcium supplements had already been added, corn starch was further added. Table 4 shows the composition of the phosphorus supplements.

TABLE 4.—*Composition of phosphorus supplements*

PHOSPHORUS SUPPLEMENT	CALCIUM	PHOSPHORUS
	%	%
Dicalcium Phosphate, reagent grade	26.50	20.50
Dicalcium Phosphate, commercial grade	33.34	19.38
Curacao Island Phosphate, commercial grade	33.34	14.19
Steamed bone meal, commercial grade	32.55	15.44
Colloidal Phosphate, commercial grade	16.8	9.8
Defluorinated Phosphate, commercial grade	35.96	18.45

Feeding was begun immediately after the poults were placed in the battery brooders. After three weeks when the experiment was concluded for each trial, the poults were weighed and five representative birds from each lot were sacrificed. Where there were five or less poults surviving the 3-week experimental period, all the surviving birds were killed for bone ash determinations following the official A.O.A.C. procedures (1950). The left tibiae were removed and cleaned by boiling for two minutes tissues adhering to the bone except the cartilage cap. The bones were then extracted with alcohol for 24 hours after which they were further extracted with ether for another 24 hours. After extraction, the bones were air-dried for six hours and then finally ashed in the muffle furnace at 550°C for at least 12 hours.

Experiment 3. The procedure of experiment 3 duplicated that of experiments 1 and 2. In experiment 3, however, some le-

vels of added phosphorus from different phosphate supplements, the ash of four unidentified growth factor supplements were added to the phosphate materials to supply an additional amount of 0.15 per cent phosphorus. The ash of the unknown factors used in this study was equivalent to 6 per cent distillers dried solubles, 3 per cent dried whey product, 3 per cent fish solubles and 3 per cent dried grass juice.

The ash of four unidentified growth factor supplements was added to find out if the availability of the phosphorus in the reagent grade dicalcium phosphate could be improved. From the results of experiments 1 and 2 it was assumed that the consistently greater availability of commercial grade dicalcium phosphate than any of the other phosphate supplements used, may be attributed to an unknown factor which it contains.

There were 13 lots in experiment 3 with 12 poults (Empire White) distributed at random in each lot. Like the poults in the previous experiments those in experiment 3 were given the same care and management, and bone ash determinations were also made.

The basal diet, mineral and vitamin mixtures were the same as in experiments 1 and 2. There were only three phosphate supplements used (reagent grade dicalcium phosphate, commercial grade dicalcium phosphate, Curacao Island phosphate). The levels of phosphorus added were 0.15 per cent, 0.30 per cent and 0.45 per cent for Curacao Island phosphate and pure grade dicalcium phosphate. Each phosphorus level of 0.15 per cent and 0.30 per cent supplementations was further supplemented with the ash of the four unknown growth factors. Levels of 0.30 per cent and 0.45 per cent added phosphorus were also used in the experiment without the addition of ash from the unknown factors. For the commercial dicalcium phosphate, an additional level of added phosphorus (0.90 per cent) was used.

RESULTS AND DISCUSSION

The average percentage of bone ash of 3-week old poults fed various phosphate materials from experiments 1 and 2 are presented in table 5.

This table shows the varying bone ash percentages among the various phosphate supplements used even when the level of phosphorus supplementation is the same, indicating that the availability of phosphorus for the poult from these supplements vary. At the

TABLE 5.—*Average percentage of bone ash of 3-week-old poults fed various phosphate materials in experiments 1 and 2*

PHOSPHORUS SUPPLEMENT	PER CENT PHOSPHORUS ADDED	BONE ASH, PER CENT	
		Experiment 1	Experiment 2
None [a]	—	—	—
Dicalcium Phosphate, reagent grade	0.23	27.78	—
Dicalcium Phosphate, reagent grade	0.46	37.72	40.47
Dicalcium Phosphate, reagent grade	0.69	45.18	46.89
Dicalcium Phosphate, reagent grade	0.92	46.82	—
Dicalcium Phosphate, commercial grade	0.46	45.71	47.06
Dicalcium Phosphate, commercial grade	0.69	—	47.87
Curacao Island Phosphate, Sample A	0.46	34.98	—
Curacao Island Phosphate, Sample A	0.46	—	42.25
Curacao Island Phosphate, Sample B	0.46	—	38.97
Curacao Island Phosphate, Sample B	0.46	—	38.99
Colloidal Phosphate, commercial grade	0.46	25.56	—
Steamed Bone Meal, commercial grade	0.46	39.65	—
Defluorinated Phosphate, commercial grade	0.46	44.45	—

[a] No survivors.

0.46 per cent level of phosphorus added in experiment 1, the percentage of bone ash was highest for commercial grade dicalcium phosphate and lowest for colloidal phosphate. Reagent grade dicalcium phosphate and steamed bone meal have very close values of bone ash percentages. The bone ash for defluorinated phosphate was slightly less than but almost equal to that of commercial grade dicalcium phosphate. In the second experiment, the bone ash values for reagent grade dicalcium phosphate and Curacao Island phosphate were again lower than commercial dicalcium phosphate at the 0.46 per cent level of phosphorus supplementation. The average value of three lots of Curacao Island phosphate was higher than the corresponding bone ash value in experiment 1 by 6.63 per cent. This higher bone ash content of the poults in experiment 2 given Curacao Island phosphate sample A compared to that of the poults given the same sample of Curacao Island phosphate in experiment 1 indicates that the response of poults from different hatches may vary for the same phosphorus supplement. The temperature when the experiments were conducted may also have contributed to the varying bone ash values.

If the availability of a phosphate material is measured primarily by the extent of bone calcification and if this in turn is determined by the ash content of the tibiae, it can be concluded that

except for colloidal phosphate, Curacao Island phosphate, and reagent grade dicalcium phosphate, the rest of the supplements like commercial grade dicalcium phosphate, steamed bone meal and defluorinated phosphate, are satisfactory as sources of phosphorus when supplying 0.46 per cent phosphorus to the basal diet for growing poults. At this level, Wilcox *et al.* (1954) obtained a very low availability for dibasic calcium phosphate and in chicks very much higher availability was obtained (Gillis *et al.* [1948], Miller and Joukovsky [1953], The Lime Crest Research Laboratory [1955]). This difference between the poult and the chick to utilize phosphorus for bone formation from a given source even when the level of supplementation is the same, may be attributed to the faster rate of growth of the poult or to a higher requirement of unknown factor required for phosphorus utilization.

Of particular interest is the poor response of the poults given the 0.46 per cent phosphorus from reagent grade dicalcium phosphate. In the first experiment, the commercial grades of dicalcium phosphate, defluorinated phosphate, and steamed bone meal were more available than the reagent grade dicalcium phosphate based on the higher percentages of bone ash of poults given the former supplements. In the second experiment, commercial grade dicalcium phosphate was again superior to the reagent grade phosphate. In view of these consistent results, it can be stated that commercial grade dicalcium phosphate, defluorinated phosphate and steamed bone meal have a higher nutritional value than reagent grade dicalcium phosphate. This finding may be attributed to the presence of certain unidentified factors in the three commercial grade phosphates which improve availability but which are absent from the pure grade dicalcium phosphate. If this theory is correct, then an addition of the ash of feeds containing unknown supplementary growth factors like those in distillers solubles, fish solubles, grass juice and dried whey to reagent grade dicalcium phosphate may greatly improve its availability to the turkey poult.

When graded levels of reagent grade dicalcium phosphate were used, the percentages of bone ash varied accordingly. As the level of phosphorus was increased from 0.23 per cent to 0.92 per cent a corresponding increase of bone ash was also obtained. This finding is in complete agreement with previous works using both chicks (Gillis *et al.* [1948 & 1954], Miller and Joukovsky [1953], The Lime Crest Research Laboratory [1955]) and poults (Wilcox *et al.* [1954]). On the basis of the percentages of bone ash for different levels of

added phosphorus from reagent grade dicalcium phosphate, it is probable that the optimum level of phosphorus supplementation using this phosphate material is 0.69 per cent. This amount is very close to the 0.55 to 0.65 per cent recommendation of Hammond *et al.* (1944) who claimed that at these levels the efficiency of feed utilization is high. The 0.92 per cent level may be more than is necessary since the percentage bone ash of poults at this amount of added phosphorus from reagent grade dicalcium phosphate is only a little higher than that of the 0.69 per cent level. With commercial grade dicalcium phosphate the evidence shows that the 0.46 per cent level of phosphorus supplementation was approximately adequate.

The effects of the ash of four unidentified factor supplements (UFS) upon utilization of phosphorus from reagent and commercial grade dicalcium phosphate are shown in table 6.

TABLE 6.—*Weight and percentage of bone ash of 3-week-old poults fed various phosphate materials with and without the ash of 4 unidentified growth factor supplements*

PER CENT PHOSPHORUS	PHOSPHATE SUPPLEMENT	PER CENT BONE ASH
0.30	Reagent Grade Dicalcium Phosphate	31.67
0.45	Reagent Grade Dicalcium Phosphate	43.86
0.15	Reagent Grade Dicalcium Phosphate plus ash of 4 UFS	39.84
0.30	Reagent Grade Dicalcium Phosphate plus ash of 4 UFS	45.28
0.30	Commercial grade Dicalcium Phosphate	42.61
0.45	Commercial grade Dicalcium Phosphate	47.39
0.90	Commercial grade Dicalcium Phosphate	49.05
0.15	Commercial grade Dicalcium Phosphate plus ash of 4 UFS	42.63
0.30	Commercial grade Dicalcium Phosphate plus ash of 4 UFS	47.14
0.30	Curacao Island Phosphate	32.52
0.45	Curacao Island Phosphate	34.49
0.15	Curacao Island Phosphate plus ash of 4 UFS	38.76
0.30	Curacao Island Phosphate plus ash of 4 UFS	43.26

A very clear indication is shown on the marked improvement of bone calcification when the ash of the four unidentified growth factor supplements is added to reagent dicalcium phosphate and Curacao Island phosphate. A higher percentage of bone ash is obtained in all levels of phosphorus supplementation with the addition of the ash of the four unknown factors to equal the amount of phosphorus supplementation but without the addition of ash in both phosphate materials used. This is probably due to either the presence in the ash of an unknown factor required for phosphorus utilization or to

a very high degree of utilization of the phosphorus in the ash. The second hypothesis appears unlikely in view of the large improvement in calcification observed when the ash was added to the 0.30 per cent level of Curacao Island phosphate.

Results of this study show that the available phosphorus requirement of the turkey poult is approximately 0.78 per cent. This requirement is obtained if the amount of phosphorus for maximum bone calcification is approximately 0.6 per cent plus one-third of the available organic phosphorus in the basal diet which contains 0.55 per cent phosphorus.

SUMMARY AND CONCLUSIONS

1. Six phosphate supplements (reagent grade dicalcium phosphate, commercial grade dicalcium phosphate, steamed bone meal, Curacao Island phosphate, colloidal phosphate, defluorinated phosphate) were used to test their availability for the turkey poult when fed at levels of 0.23, 0.46, 0.69, and 0.92 per cent phosphorus using a purified basal diet containing approximately 0.55 per cent organic phosphorus.

2. Based on the percentages of bone ash at the 0.46 per cent level of phosphorus supplementation, commercial grade dicalcium phosphate, defluorinated phosphate, and steamed bone meal had higher availability than Curacao Island phosphate, reagent grade dicalcium phosphate and colloidal phosphate for the poult.

3. Bone calcification was improved when the ash of four unidentified growth factors was added to various levels of phosphorus from reagent grade dicalcium phosphate and Curacao Island phosphate but not from commercial grade dicalcium phosphate.

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RICE MILLS AND COST OF MILLING PALAY IN NUEVA ECIJA [1]

BENJAMIN D. PEREDO, E. J. ECHON and P. C. KUHONTA [2]

WITH FIVE TEXT FIGURES

There were 374 estimated rice mills in Nueva Ecija.

The average milling recovery of "kiskisan" mills was 59 per cent and of the "conos," 67 per cent by weight.

The annual operating cost per mill for the kiskisans was ₱1570; the commercial conos, ₱10,329; and the FaCoMa conos, ₱7605. The average cost of milling a cavan of palay was ₱0.61 for the kiskisan; ₱0.60 for the commercial cono; and ₱0.67 for the FaCoMa cono.

The volume of palay milled was the most important factor directly affecting the cost of milling.

To break-even, the kiskisan mills should mill about 5000 cavans of palay per year, and commercial conos about 38,000.

The two per cent tax and the addition of premix were the primary complaints of the millers.

Rice milling is one of the important functions in marketing palay. Its efficiency affects the supply of rice of the rice-consuming population of the Philippines. The cost and quality of milled rice largely determine how much and how well consumers eat.

Mondoñedo [3] claimed that although a state of self-sufficiency in palay had already been attained, there is still a shortage of rice. He explained that this discrepancy was due to deficiency and losses in milling palay. He further indicated that a 10-per cent increase in milling recovery among "kiskisan" and "cono" rice mills would be more than sufficient to cover the national deficit.

Closely related to the efficiency of the mills is the cost of the milling operation. It is one of the factors that determine the ultimate cost of rice in the market.

For the prosperity of the palay millers, and for the benefit of the rice consumers and government agencies engaged in transac-

[1] Central Experiment Station Contribution No. 868. This study was made possible by a grant from the NARIC.

[2] The authors acknowledge the assistance of Dr. Glenn W. Hedlund, visiting Cornell professor, in the survey and in the preparation of the manuscript.

[3] O. Mondoñedo, *The Cooperative Farmer*, 3, 10 (1955).

tions of this staple commodity and policy-making functions, a fairly accurate knowledge of the current palay milling situation, and measures to improve the efficiency of mills and reduce milling costs of palay, are necessary. This work aims therefore to study: (1) milling facilities and practices, (2) efficiency of mills, (3) costs of operation of kiskisan and cono rice mills and (4) the factors influencing the costs of milling.

CHARACTERISTICS OF THE STUDY

This study, conducted through personal interviews with millers in the province of Nueva Ecija in April and May, 1956, was divided into two phases. The phase which was conducted in all municipalities, except in the town of Pantabangan, dealt with the rice mills and their facilities. The second phase concentrated on the cost aspects of milling palay and actual performance tests on milling recovery which were administered with the cooperation of the Department of Agricultural Engineering. Information on milling costs was for the 1955-56 fiscal year.

The field work for the first part of the study was accomplished through surveys to all rice mills in the province. The municipal treasurers' lists of rice mills were used as guides for locating the mills. One hundred eighty-eight rice mills (129 kiskisans and 59 conos) were surveyed and from these a random sample based on type of mill, mill size (milling capacity per 12-hour operation), and ownership of rice mills was drawn. Each type of mill—kiskisan, commercial cono and FACOMA cono—was divided into three size groups. Ten mills each for the first and last groups and 15 for the middle one among kiskisan rice mills were included. Each group among the commercial cono rice mills was represented by 10 mills and among the FACOMA mills the first by four and the second and last by five each. When the mill operator in the sample was not available for interview, the succeeding operator on the list was interviewed. Of those included in the sample, one from the last group of kiskisan, one each from the first and second groups of commercial mills and one for the first and three for the last group of the FACOMA mills were not used in the final analysis because of insufficient information.

This study has some limitations. Among them was the tendency of millers to under-report volume of milling and income. The tax on gross value of milled palay suggests such a possibility. Because

of this the data on gross and net income and cost per cavan should be discounted.

Another limitation was the fact that the study covered only the milling operation when many millers, particularly the larger ones, engaged in other functions of palay marketing such as assembling, storing, buying and selling, and others. This made it necessary to allocate joint costs arbitrarily. Even though the milling enterprise showed a loss, the other activities of the millers may have offset them so that the entire business showed a profit.

LOCATION AND OWNERSHIP OF RICE MILLS

Nueva Ecija, commonly known as the "Rice Granary of the Philippines", had a total production of 4,810,530 cavans of palay [4] grown on 183,570 hectares in 1954. It was surpassed only by Pangasinan with 6,005,360 cavans palay harvested from 187,350 hectares of cropland.

A large number of rice mills and warehouses are geographically distributed throughout the 30 municipalities which include the three newly established towns of Gabaldon, Llanera and Talugtug. The lists from the municipal treasurers showed a total of 312 rice mills consisting of 228 kiskisans and 84 conos (table 1). The interviewers, nevertheless, found 31 rice mills not included in the municipal lists, indicating that the municipal lists were not complete. Of the 188 mills surveyed, 157 mills were listed by the municipal treasurers.

Because the writers ran across 31 unlisted mills in the course of interviewing half of the listed ones they assumed that they would have found a total of 62 unlisted mills had they interviewed all the listed ones. Therefore, the total number of mills in the province is estimated to be 374 (312 plus 2×31).

The operating kiskisans are concentrated in Aliaga, Cabanatuan, Cuyapo, Guimba, Llanera, Muñoz, Rizal and Talavera while the cono mills are in Cabanatuan, Cabiao, Gapan, Jaen, San Jose and San Leonardo. Of the 129 kiskisan and 59 cono rice mills surveyed, 59 and 15, respectively, were located either in barrios and suburbs. The geographical distribution of rice mills was related to the amount of palay produced [5] in the municipalities and neighboring areas (fig. 1).

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[4] Philippine Agricultural Statistics, Vol. II, 1954.
[5] Philippine Census, Vol. II, 1948.

TABLE 1.—*Distribution of rice mills in 29 municipalities of Nueva Ecija*

MUNICIPALITY	MUNICIPAL RECORDS		NUMBER SURVEYED			
			Included in municipal lists		Not included in municipal lists	
	Kiskisan	Cono	Kiskisan	Cono	Kiskisan	Cono
Aliaga	12	1	3	1		
Bongabon	4	4 [a]		2		
Cabanatuan	10	8		4		
Cabiao	11	5	3	4	1	
Carranglan	7		2			
Cuyapo	19	2	9	2		
Gabaldon	7		3		1	
Gapan	5	8	4	5	1	2 [a]
Guimba	16	3	6	2	1	
Jaen	8	5	1	4		
Laur	6	2	2	1	1	
Licab	9	1	6	1	2	
Llanera	7		4		1	
Lupao	10	1	7	1	1	1
Muñoz	15	4	7	1	2	
Nampicuan	2		1			
Papaya	3	4	2	3		
Peñaranda	1	1		1		
Quezon	5	1	5	1		
Rizal	13	4	3	2	2	
San Antonio	5	3	2	1	2	
San Isidro	8	4	4	4		
San Jose	8	6	4	5	4	
San Leonardo	3	5	2	2		
Sta. Rosa	4	3	4	2	1	1
Sto. Domingo	8	2	5	1	3	
Talavera	11	4	6	3	2	
Talugtug	6		4			
Zaragoza	5	3	3	2	2	
Total	228	84	102	55	27	4

[a] Includes one semi-cono rice mill.

The most common form of ownership in the province was the single proprietorship. Only one was owned by a Filipino corporation and 14 by farmer-cooperative associations. No Chinese acknowledged ownership of kiskisan mills nor employment as a FACOMA manager. Only seven of them reported owning commercial cono mills. Most of the Chinese mills were located in regions such as Cabanatuan, San Jose, Cuyapo and Muñoz where palay production was high.

Fig. 1.—Rice mill distribution in Nueva Ecija

COMPARISON BETWEEN KISKISAN AND CONO RICE MILL OPERATIONS

Cono mills are larger, installed in bigger mill houses, and are more complex in structure than the kiskisan mills. Generally, cono mills are found in larger towns and cities and the kiskisan mills in barrios. A cono mill is often built together with warehouse which is frequently a separate building.

Milling capacity per 12 hours. The milling operation of cono mills is longer than that of the kiskisan mills because they have the capacity to mill more palay within a certain time, provided there is palay to be milled, than kiskisan mills. Besides, in cono mills hulled and unhulled palay undergo several polishings whereas, in kiskisan mills only one and rarely two polishings are undergone during the process. The higher degree of polishing in cono mills make it possible to obtain milled rice of higher quality. In Nueva Ecija, the milling capacity per 12-hour operation of the kiskisan mills ranged from 22 to 240 cavans of palay or an average of 90; whereas that of cono mills, from 70 to 600 cavans of palay or an average of 199. Semi-cono rice mills were classified as cono mills.

The reported horsepower of the kiskisan engine averaged only 16 as contrasted with 47 for cono engine.

Rice enrichment. In kiskisan, commercial and FACOMA cono rice mills, the standard rice enrichment of 280 grams of premix to a cavan of 56 kilograms of milled rice was not strictly followed. Rice enrichment was primarily performed by the cono millers. Seventy-two of the 129 kiskisan millers, and 52 of the 59 cono millers, partially complied with the law. The others added no premix. The kiskisan millers who added premix had a discrepancy averaging 63 grams of premix per cavan of rice from the standard requirement whereas, the cono millers had an average discrepancy of only 26 grams. The difference might be explained by the report that some kiskisan customers, especially the farmers who bitterly resented the practice, decided the quantity of premix to be added. However, among cono mills this desire of the customers did not apply because the larger volume of palay milled is channeled to market where its required mixing proportion could be detected by the law.

The milling charge. With the recent enactment of the rice enrichment law, the basis of charging for milling palay was altered. Without premix, the average charge by kiskisan millers was ₱0.39 per cavan palay of 46 kilograms and by cono millers it was ₱0.68 per cavan rice of 56 kilograms. With premix, the kiskisan millers

collected an additional fee averaging ₱0.16 per cavan palay and the cono millers, ₱0.20 per cavan rice, in addition to regular charge for milling.

Procurement of palay and disposal of milled rice. The farmers constituted the major source of palay in both kiskisan and cono mills (table 2). Customarily, small farmers bring their palay to kiskisans because cono mills refuse to mill in small volume and are not as accessible. The milling fee for small amounts of palay is not sufficient to interest cono millers.

Though 70 per cent of the cono millers' palay came from farmers, this was not milled in small quantities for them but was purchased gradually for storage and future milling. Cono mills were preferred by buyers and dealers and proprietors who were engaged in marketing rice.

The 99 per cent which represented the farmers as outlet meant that kiskisan millers operated almost exclusively for small farmers as mentioned above. In cono mills, the greater bulk of palay did not find its way back to the farmers but instead was channeled to local retailers, local wholesalers and transient buyers.

TABLE 2.—*Sources of palay and outlets of milled rice of kiskisan and cono rice mills*

ITEM	PERCENTAGE OF PALAY RECEIVED AND CLEAN RICE DISPOSED	
	Kiskisan	Cono
Sources		
Farmers	99.6	70.3
Buyers and dealers	0.1	11.4
Proprietors	0.3	16.3
Others [a]	—	2.0
Outlets		
Farmers	98.8	18.9
Local retailers	0.5	40.0
Local wholesalers	0.6	18.2
Transient buyers	—	18.2
Others [b]	0.1	4.7

[a] Includes non-farmers and millers.
[b] Includes non-farm consumers.

MILLING RECOVERY

The milling recovery in this study, except that obtained from the milling tests conducted by the cooperating team of agricultural

engineers on 25 of the 59 cono mills, was computed from estimates of input and output (both in cavans and kilograms of palay and rice) rendered by the millers. In both cases, the milling recovery was expressed in terms of percentage by weight.

The percentage weight was computed by dividing the total weight in kilograms of the recovered rice by the total weight of palay milled and multiplying by 100.

Strikingly, the milling recovery of clean rice of cono mills was higher than that of the kiskisan mills (tables 3 and 4). The comparable percentage milling recovery of clean rice for all conos was 67 per cent whereas that of the kiskisans was 59 per cent.

TABLE 3.—*Milling recovery of kiskisan rice mills*

MILLING CAPACITY (PALAY) PER 12 HOURS	NUMBER OF MILLS	MILLING CONSTITUENTS		
		Clean rice	Bran and hull	Difference
		percentage weight		
Below 75	46	58.18	35.99	5.83
75–100	52	59.07	34.87	6.06
Above 100	31	59.79	36.18	4.03
All	129	59.01	35.68	5.31

TABLE 4.—*Milling recovery of cono rice mills*

MILLING CAPACITY (PALAY) PER 12 HOURS	NUMBER OF MILLS	MILLING CONSTITUENTS			
		Clean rice	Brewers' rice	Bran	Difference
			percentage weight		
Cono (Commercial)					
Below 150	15	66.30	1.12	7.90	24.68
150–200	18	66.70	1.46	8.51	23.33
Above 200	12	66.84	1.17	9.33	22.66
Average		66.60	1.28	8.52	23.60
Cono (FaCoMa)					
Below 150	4	66.45	1.66	10.17	21.72
150–200	5	67.19	1.97	9.68	21.16
Above 200	5	69.72	2.73	11.30	16.25
Average		67.89	2.16	10.39	19.56
All	59	66.90	1.48	8.97	22.65

Umali *et al.*,[6] in their study of the milling efficiency of five kiskisan rice mills in Los Baños, found that the percentage milling re-

[6] Umali, *et al.*, *Philippine Agriculturist*, **40**, 77 (1956).

covery of clean rice was 62 per cent. However, relatively small samples of 14.67 kilograms of Seraup Ketchil and 22 kilograms of Wagwag, were used in the milling tests.

The milling recovery of clean rice obtained from estimates of the 59 cono millers almost concurred with the findings of a team of agricultural engineers on 25 of the 59 cono millers. The average milling recovery of clean rice based from the millers' estimates was 66.90 per cent whereas, that from the actual test was 67.03 per cent (table 5). This would indicate that the cono millers had neither been too pessimistic nor optimistic in their estimates. The agricultural engineers did not conduct actual milling tests on kiskisan mills because of the insufficiency of palay brought in by the customers.

COST OF MILLING PALAY

The economic considerations of milling palay cover mainly cost factors and income (milling charge per cavan palay or per cavan rice) for the period of May, 1955 to April, 1956 and which were attributable only to milling.

The investment. The primary items of investment were land and buildings, mill apparatus, power unit and others.

The land item considered in this study was the space occupied by the building used for milling only. The part of the mill building used for storing palay was excluded. Palay mill apparatus included all the set-ups needed to mill palay except the engine which was considered as a separate item. The items included in others consisted of generators, weighing scales, water pumps and blowers with values equitably divided between milling and warehousing as separate business processes.

Comparatively, the investments of the commercial and FACOMA cono rice mills were exceedingly higher than that of the kiskisan mills (table 6).

Annual milling cost. The average annual milling costs per kiskisan mill was ₱1570 as compared to ₱10,329 for the commercial cono and ₱7605 for the FACOMA cono rice mills (table 7).

On the basis per cavan palay milled, the average milling cost for kiskisan was ₱0.61; for commercial cono, ₱0.60; and for FACOMA cono, ₱0.67 (table 8).

TABLE 5.—*Milling efficiency of 25 cono mills in Nueva Ecija* [a]

VARIETY	NUMBER OF MILLS	MOISTURE CONTENT AT MILLING	MILLING CAPACITY PER 12 HOURS	MILLING CONSTITUENTS			DIFFERENCE	QUALITY OF PRODUCTS			
				Polished rice	Brewers' rice	Bran		Whole grain	¾ grain	½ grain	¼ grain
				percentage weight				*per cent*			
Ordinario	14	14.09	209	67.12	0.81	7.50	24.57	60.99	5.88	18.68	14.45
Special [b]	7	14.69	163	67.51	0.49	7.38	24.62	63.04	5.17	18.68	13.11
Fancy [c]	4	14.30	206	65.89	1.04	9.86	23.21	72.67	2.77	9.78	14.78
All	25	14.28	196	67.03	0.76	7.84	24.37	63.43	5.18	17.26	14.13

[a] Findings of the Department of Agricultural Engineering, College of Agriculture, U.P., 1956.
[b] Includes Raminad, Burma and Los Baños.
[c] Includes Wagwag.

TABLE 6.—*Average investments of kiskisan, commercial and FaCoMa cono rice mills, 1956*

ITEM	KISKISAN	COMMERCIAL CONO	FACOMA CONO
Number of mills	34	28	10
	pesos	*pesos*	*pesos*
Land and building	1284	6175	8808
Rice mill	779	14751	14932
Power unit	2165	8102	11390
Other [a]	79	422	464
Total	4307	29450	35594

[a] Includes generators, weighing scales and water pumps.

TABLE 7.—*Average annual milling costs per mill in Nueva Ecija, 1955-56*

COST ITEM	KISKISAN	COMMERCIAL CONO	FACOMA CONO
No. of mills	34	28	10
No. of cavans palay milled	2555	17090	11335
	pesos	*pesos*	*pesos*
Land and building			
Depreciation	57	339	312
Repairs	12	47	50
Rent	4	115	46
Machinery			
Depreciation	394	1561	1607
Repairs and spare parts	157	614	88
Rent	—	—	95
Interest on investment (6%)	258	1767	2136
Labor	307	2724	2107
Fuel and oil	232	1213	686
Electricity and water	4	31	22
Insurance	6	553	307
Taxes	131	1289	[a]
Other [b]	8	76	149
Total costs	1570	10329	7605
Income	1090	7009	4371
Net profit or loss	–480	–3320	–3234

[a] FaCoMa mills are exempted from some taxes. None reported paying taxes for the year 1955-56.

[b] Include belt dressing and blank receipts, etc.

According to Mondoñedo,[7] NARIC spent ₱0.60 for milling a cavan of palay in Central Luzon.

TABLE 8.—*Weighted average milling cost per cavan palay in Nueva Ecija, 1955-56*

COST ITEM	KISKISAN	COMMERCIAL CONO	FACOMA CONO
No. of mills	34	28	10
Land and building			
Depreciation	0.02	0.02	0.02
Repairs	0.01	[a]	[a]
Rent	[a]	0.01	[a]
Machinery			
Depreciation	0.15	0.09	0.14
Repairs and spare parts	0.06	0.04	0.01
Rent	—	—	0.01
Interest on investment (6%)	0.10	0.10	0.19
Labor	0.12	0.16	0.19
Fuel and oil	0.09	0.07	0.06
Electricity and water	[a]	[a]	[a]
Insurance	[a]	0.03	0.03
Taxes	0.05	0.08	
Other	[a]	[a]	0.01
Total costs	0.61	0.60	0.67
Income	0.42	0.41	0.39
Net profit or loss	–0.18	–0.19	–0.28

[a] Less than ₱0.01.

The depreciation of machinery in kiskisan mills contributed 25 per cent of the costs. This might be attributed to the fact that machinery in kiskisan mills accounted for about 50 per cent of the total investment. Furthermore, kiskisan machinery had shorter expected useful life than that of the conos so that higher depreciation cost was reflected. Labor cost was 20 per cent; interest on present investment, 16 per cent; fuel and oil, 15 per cent of the total cost.

The commercial conos had the highest total annual milling cost per mill, ₱10,329. This might be explained by the greater volume of palay milled and by the higher percentage of milling capacity used. Labor cost was the greatest single item, contributing about 26 per cent of the total costs. Interest on the present investment was 17 per cent; machinery depreciation, 15 per cent; taxes, 15 per cent; fuel and oil, 12 per cent of the total costs.

[7] ACCFA Administrator O. Mondoñedo's Memorandum to the President of the Philippines, "Rice Importation", August 23, 1956.

In the FACOMA mills, the interest on the present investment, labor and machinery depreciation totalled ₱5850 and comprised about 77 per cent of the total expenses.

Expenses for labor, fuel and oil, repairs and spare parts of machinery and taxes were the major cash operating costs. The sum of these cash expenses contributed an average of no more than 55 per cent of the total milling costs per mill or per cavan of palay milled in kiskisan mills, 64 per cent in commercial conos, and 46 per cent in the FACOMA conos.

The non-cash expenses such as the depreciation of the machinery, land and building, and interest on present investments, contributed an average of 45 per cent of the total costs of operation in kiskisan mills, 36 per cent in commercial conos, and 54 per cent in FACOMA conos.

FACOMA conos had smaller cash operating expenses than the cono mills, probably because FACOMA conos are exempted from some taxes and the machinery being newly purchased, necessitated few expenses on repairs and spare parts. However, FACOMA conos had higher non-cash expenses. This might be attributed to their greater investments and interest which was ultimately reflected in the non-cash costs. As a consequence, the depreciation was also large.

FACTORS AFFECTING THE COST OF MILLING PALAY

Volume. The kiskisan mills had an annual volume of palay milled ranging from 197 to 9300 cavans or an average of 2555. As volume of palay increased the cost per cavan decreased regardless of milling charge collected (table 9).

TABLE 9.—*Relation of volume of palay milled to cost in kiskisan rice mills*

CAVANS PALAY MILLED	NUMBER OF MILLS	MILLING CHARGE PER CAVAN PALAY	MILLING COST PER CAVAN PALAY
Below 1300	12	0.41	1.26
1300–2500	11	0.45	0.88
2500 and above	11	0.41	0.41
All	34	0.42	0.61

The non-linear trend (fig. 2) which was drawn free hand, indicated that the milling cost decreased rapidly up to a volume of about 300 cavans palay. Beyond this limit up to 5000 cavans,

the milling cost gradually decreased and over 5000 it appeared to level off or remain more or less constant. At this point the milling cost ranged from ₱0.30 to ₱0.50 per cavan palay.

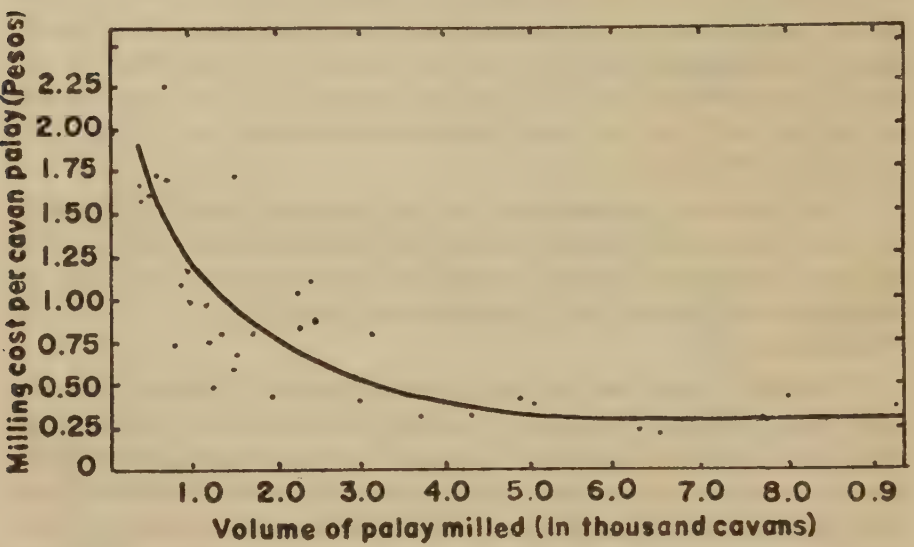

Fig. 2.—Relation of volume to milling cost per cavan palay, 34 kiskisan rice mills, 1955-56

Among the commercial conos the volume of palay milled ranged from 800 to 50,000 cavans or an average of 17,090. As in the case of kiskisan mills, the milling cost decreased as the amount of palay increased regardless of the milling charge (table 10).

TABLE 10.—*Relation of volume of palay milled to costs in commercial cono rice mills*

CAVANS PALAY MILLED	NUMBER OF MILLS	MILLING CHARGE PER CAVAN PALAY	MILLING COST PER CAVAN PALAY
		pesos	
Below 10000	8	0.39	1.01
10000–20000	12	0.39	0.72
Above 20000	8	0.43	0.48
All	28	0.41	0.60

The relation of the amount of palay milled to milling cost in commercial conos as shown graphically indicated that the milling

cost decreased rapidly up to a volume of about 20,000 cavans of palay (fig. 3).

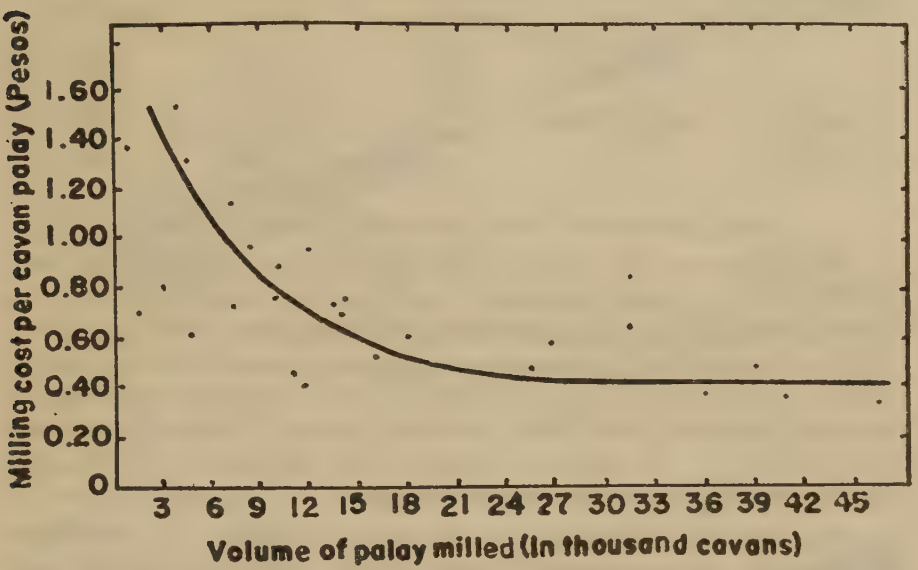

Fig. 3.—Relation of volume to milling cost per cavan palay, 28 commercial cono rice mills, 1955-56

Density of mills. To some extent the number of mills in a town will affect the amount of palay milled and probably the milling charge and milling cost. In this study, the fewer the number of kiskisan mills per town, the more palay was milled and the lower the milling cost (table 11). This was most probably due to less competition among mills.

TABLE 11.—*Relation of density of kiskisan rice mills to volume and cost*

NUMBER OF KISKISAN RICE MILLS PER TOWN	NUMBER OF MILLS	MILLING CHARGE PER CAVAN PALAY	AMOUNT PALAY MILLED	MILLING COST PER CAVAN PALAY
		cavans	*palay*	*pesos*
1–5	12	0.47	3176	0.52
6–10	15	0.39	2351	0.58
11–19	7	0.43	1930	0.95
All	34	0.42	2555	0.61

A similar situation was found among the commercial cono mills (table 12).

TABLE 12.—*Relation of density of commercial cono rice mills to volume and cost*

NUMBER OF COMMERCIAL CONO RICE MILLS PER TOWN	NUMBER OF MILLS	MILLING CHARGE PER CAVAN PALAY	AMOUNT PALAY MILLED	MILLING COST PER CAVAN PALAY
		pesos	*cavans*	*pesos*
1–3	8	0.42	22282	0.56
4–6	15	0.40	15999	0.58
7–9	5	0.40	12060	0.81
All	28	0.41	17090	0.60

THE "BREAK EVEN" POINT ANALYSIS OF MILLING PALAY

For businesses like milling palay, the break-even chart is a useful device for bringing together diverse facts in one comprehensive picture as an aid in managerial control. It depicts the relationship of the volume milled to income and expenses. One of its significant features is the break even point or the level of volume (cavans of palay) of operation that brings in enough income to meet the expenses at that level. The degree of profit or loss depends on how far the amount milled is above or below the level.

To determine the break-even point in this analysis the expenses were divided into two classifications namely, fixed and variable expenses. The fixed expenses are those which remain constant or change very little with changes in volume. They include depreciation, repair of mill building, rent, interest on investment and insurance. The variable expenses, which vary directly with changes in volume, included equipment repairs and spare parts, fuel and oil, electricity and water. Items such as labor, taxes, and minor expenses were classified as fixed or variable depending on methods of labor payment, basis of tax collection and regularity of reporting minor expenses (tables 13 & 14).

The sum of the fixed expenses was plotted at point "A" on the vertical axis. This was projected parallel to the horizontal axis. The total expense (combined fixed and variable expenses) at average volume of operation was plotted at "B". A line drawn from "A" through "B" indicates total expenses at various levels of operation (figs. 4 & 5).

The gross income at average volume of operation was plotted at point "C". A line drawn from the origin through point "C" represents the gross income at various levels of operation. The point where the two lines (total expense and gross income) at various levels of operation. The point where the two lines intersect is the break even point.

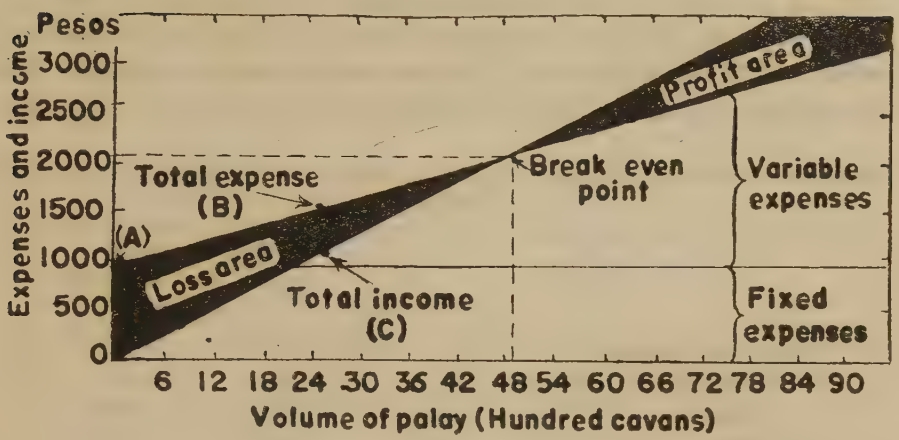

Fig. 4.—Break even point of 34 kiskisan rice mills, 1955-56

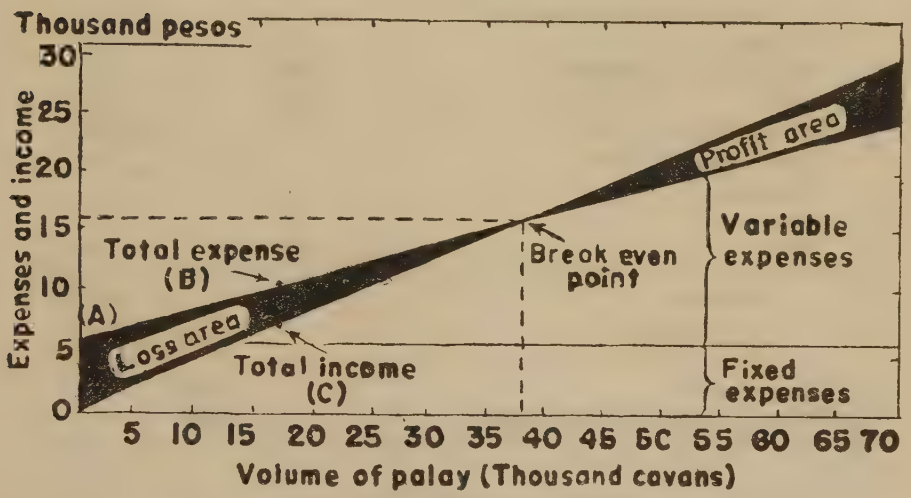

Fig. 5.—Break even point of 28 commercial cono rice mills, 1955-56

The cost analysis of this study indicated that for the different types of mills to break even, at least the following volumes of palay should be milled: kiskisan, 5000; commercial cono, 38,000 cavans of palay.

In connection with the break even analysis of the 1955-56 milling operation in Nueva Ecija, it is pertinent to recall that the kiskisan millers operated only on the average of 28 twelve-hour days

with an average of 2555 cavans of palay or 2445 cavans short of the break even point; the commercial cono, 78 days with 17090 cavans or 20,910 cavans short. This and earlier analysis indicate that the average mill does not have enough palay to operate efficiently.

TABLE 13.—*Average fixed and variable expenses of the kiskisan rice mills, 1955-56*

COST ITEMS	MILLING EXPENSES	
	Fixed	Variable
	pesos	
Land and building		
Depreciation	57	
Repair	12	
Rent	4	
Machinery		
Depreciation	394	
Repairs and spare parts		157
Rent	—	—
Interest on investment	258	
Labor	116	191
Fuel and oil		232
Electricity and water		4
Insurance	6	
Taxes	74	57
Other	2	6
Sub-total	923	647
Grand total	1570	
Gross income	1090	
Volume of palay milled, cavans	2555	

FACTORS AFFECTING LABOR COST

Methods of labor payment. Labor was a big contributor to the total costs of milling palay particularly in cono mills. Among the kiskisan mills the piece and percentage of gross income methods of labor payment seemed to be the most economical (table 15). On these bases labor varied directly with the volume of palay milled.

Among the cono mills the piece and the combination methods of labor payment were less expensive than the monthly and daily bases (table 16).

TABLE 14.—*Average fixed and variable expenses of the commercial cono rice mills, 1955-56*

COST ITEMS	MILLING EXPENSES	
	Fixed	Variable
	pesos	
Land and building		
Depreciation	339	
Repair	47	
Rent	115	
Machinery		
Depreciation	1561	
Repairs and spare parts		614
Rent	—	—
Interest on investment	1767	
Labor	1073	1651
Fuel and oil		1213
Electricity and water		31
Insurance	553	
Taxes	246	1043
Other	18	58
Sub-total	5719	4610
Grand total	10329	
Gross income	7009	
Volume of palay milled, cavans	17090	

TABLE 15.—*Relation of the methods of labor payment to labor cost in kiskisan rice mills*

METHODS OF LABOR PAYMENT	NUMBER OF MILLS	AMOUNT PALAY MILLED	LABOR COST PER CAVAN PALAY MILLED
		cavans	*pesos*
Monthly	8 [a]	3042	0.13
Daily	10	2234	0.15
Piece	5	2745	0.05
Percentage of gross income	8	2654	0.10
Combination	3	1750	0.19

[a] Three were provided free meals and in addition one of them received one cavan of rice every month.

TABLE 16.—*Relation of the methods of labor payment to labor cost in cono rice mills*

METHODS OF LABOR PAYMENT	NUMBER OF MILLS	AMOUNT PALAY MILLED	LABOR COST PEP CAVAN PALAY MILLED
		cavans	*pesos*
Monthly	3	9467	0.22
Daily	4	4854	0.21
Piece	5	8844	0.15
Combination	25	19094	0.16

PROBLEMS OF THE RICE MILLERS

The situation. A great percentage of kiskisan and cono millers complained about the present system of taxation (table 17). This grievance was felt more among the kiskisan millers than among the cono millers who operated on a larger scale. Millers reported that different methods of levying taxes were used. They reported that the 2 per cent Bureau of Internal Revenue tax was sometimes based on: (1) the value of palay milled which may either be for sale or milled on the custom basis, (2) value of palay milled and its by-products, and (3) value of palay milled plus milling fee. A 2 per cent tax on the value of ₱10 palay is a tax of ₱0.20 per cavan. This is

TABLE 17.—*Problems of kiskisan and cono millers*

PROBLEMS	KISKISAN MILLERS WHO MENTIONED EACH PROBLEM		CONO MILLERS WHO MENTIONED EACH PROBLEM	
	number	*per cent*	*number*	*per cent*
Taxation	107	84.3	29	54.7
Premix	38	29.2	13	24.5
Competition	10	7.9	1	1.9
High expense for rentals, repairs and spare parts	1	.8	4	7.5
Lack of customers	4	3.1	1	1.9
Poor milling recovery	4	3.1	1	1.9
Labor expense	—	—	4	7.5
Poor quality of milled rice	—	—	2	3.8
Need for better mills	2	1.6	—	—
Lack of transportation facilities	2	1.6	—	—
Alien control	—	—	1	1.9
Standardization of weights	1	.8	—	—
No warehouse available	—	—	1	1.9
Availability of market	—	—	1	1.9
Felt need of government help	—	—	1	1.9
No problem	7	5.5	10	18.8

equivalent to one-half the usual milling fee in kiskisan mills and to 45 per cent of the average milling fee in cono mills. Such a high rate of taxation, almost 50 per cent of gross income, naturally results in complaints and presumably in much tax evasion.

Another big problem aired was the requirement that millers add premix. Customers generally did not agree to pay higher fee. Operators found no other recourse than to reduce the use of premix to a maximum and add sub-standard dosages. Besides, the unfavorable taste of rice was commonly disliked by the customers.

Other minor problems mentioned, especially by the kiskisan millers, were the lack of customers and palay to be milled and poor milling recovery. These are true because of the prevalence of many kiskisan mills and the resulting keen competition.

Only a few millers reported no grievances.

Tenure status. Despite the problems mentioned by the millers, 64 per cent of the kiskisan millers and 85 per cent of the cono millers indicated that they intended to stay in business, most probably hoping for better prospects or because there was lack of alternatives.

Twenty-six per cent of the kiskisan millers and 8 per cent of the cono millers planned to quit the milling business. Others did not report make definite statements about their future plans.

APPLICATION AND RECOMMENDATIONS

On the basis of information obtained from this study, the following are recommended for the improvement of the milling situation in Nueva Ecija:

1. The milling recovery of clean rice from cono mills was better and higher by 8 per cent of their total recovered weight than that from the kiskisan mills. By gradually replacing the old-type kiskisan mills which are still dominant in the area, the milling recovery will be improved in quality and quantity.

2. The milling costs per cavan palay in kiskisan and cono mills were about the same but were more than the usual milling fee. The three big contributors to the total costs of milling were the non-cash expenses on depreciation, interest on investment, and the cash expenses on labor. Some millers can reduce the cost of labor by adopting the piece and percentage of gross income bases of labor payment.

3. There were kiskisan and cono millers who gained in their milling businesses, but on the average of all who reported, both types of millers lost because of the insufficient volume of palay milled. The large number of mills tended to reduce the amount of palay per mill, thus increasing the milling costs and reducing the income. In order that the different types of mill will keep costs as low as the usual milling fee kiskisans should mill a minimum of about 5000 cavans of palay per year, and commercial conos about 38,000.

4. The millers reported that the taxes on their businesses were exceedingly high. They suggested that the two per cent Internal Revenue tax be based on the milling capacity (palay) per 12 hours of the mill or on the milling charge per unit milled. To check the amount palay milled within a certain time the government can probably install a mechanical device which will follow the principle of the hour-meter of the tractor.

5. The millers reported that customers, especially the farmers, complained of the higher milling fee for the addition of premix and the disagreeable taste of the enriched rice. The farmers and millers proposed that the practice be made optional.

* * *

We know the mean age, the average number of children, the median number of school years completed of waitresses, gasoline station attendants, and prostitutes. We have accumulated enough undigested—and undigestible—data to give any science an upset stomach.

—*R. L. Ackoff*

IN MEMORIAM: DR. ROBERT L. PENDLETON

It is with a deep feeling of grief that we record the death of Dr. Robert L. Pendleton, on June 23, 1957 in Bangkok, Thailand. Dr. Pendleton served the College of Agriculture from 1923 to 1935 as professor of soils. He was of the belief that there should be active research work in pedology in order to accumulate data on Philippine soils. Such data will be a better source of instructional material in the College than those obtained under temperate Occidental conditions. His great love for work dealing with tropical soils made him keep an active interest in the progress of soils research in the College even after he left the Philippines. He saw to it that in Johns Hopkins University, which he joined in 1935, he got assignments dealing with the soils of Southeast Asia. This eventually brought him to Kasetsart University in Bangkok, Thailand.

Dr. Pendleton was a member of the Sigma Xi and a charter member of the Society for the Advancement of Research. He is internationally recognized as one of the world's eminent pedologists and geographers.

N. L. GALVEZ
Head
Department of Soils

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